AN ACADEMIC ACCOUNTING MODEL FOR COMMUNITY COLLEGES

BY

PATRICK J. BIBBY

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Patrick J. Bibby

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Chairman: Dr. James L. Wattenbarger
Major Department: Educational Administration and Supervision

The purpose of this study was to develop an academic accounting model to monitor internally the instructional programs at community colleges. The two components of the model were (a) a faculty workload model and (b) a productivity model.

The faculty workload model consisted of seven categories of faculty activity and a workload point system. One full-time equivalent faculty (FTEF) was equated to 60 points.

For the purpose of this study, enrollment was measured in terms of student credits and productivity was defined as a ratio: the number of student credits produced per FTEF. The productivity model, in terms of student credits and workload points, was given by the equation

$$P = \frac{60 \times SC}{AP} ,$$

where P is productivity, SC is the number of student credits produced, and AP is the number of workload points assigned.

The productivity model can be used to compute productivity at almost any level of aggregation, e.g., a single class, a group of courses, a department, or a campus. For a single class or a group of

courses, the relationships between productivity and class size were presented in four theorems.

The major applications of the study consisted of selected demonstrations. In each demonstration, it was shown that a desired productivity can be achieved at one level of aggregation by controlling certain variables within sub-levels. In particular, it was shown that a desired department productivity can be achieved by controlling average class sizes of homogeneous groups of courses and that a desired campus productivity can be achieved by controlling the productivities of departments.

CHAPTER I

INTRODUCTION

The access revolution in American higher education began shortly following World War II with the enactment of the Servicemen's Readjustment Act. This and subsequent federal incentive programs, such as Basic Educational Opportunity Grants (Pell Grants) and College Work-Study, have provided more opportunity for higher education to more citizens than ever before in American history. As a result, today's colleges and universities are confronted with a more diverse student population. In fact, the teaching-learning process itself has changed in order to accommodate the changing clientele.

Community colleges are in the forefront of the movement to accommodate diversity. They are unique among all the various types of postsecondary institutions in the degree to which they are committed to the goal of expanding educational opportunity. According to Cross (1979), "ninety-nine percent of the community colleges . . . are open admissions colleges" (p. 4). Consequently, the diversity of the students attending these institutions is pronounced. The efforts of the community colleges to adapt their instructional programs to meet new needs have resulted in what Cross (1976) referred to as "an instructional revolution."

> It appears that what started as a simple approach to equality through lowering the access barriers . . . has turned into an educational revolution. . . . The revolution has reached the heart of the educational enterprise--the instructional process itself. . . . The pressure to "invent" the new [instructional] methods comes from an increasing awareness that the old methods are no longer adequate to fit our needs. (p. 9)

Within a community college, the accomplishment of change in any instructional program requires that educational decisions be made. Such

decisions cannot be made in isolation from their economic consequences. Academic administrators must be able to determine whether or not the college can afford a proposed change in one or more instructional areas before the change is implemented. The future economic impact of an educational decision on the institution must be one of the inputs into the decision-making process. The economic impact can be determined, to a great extent, by the consequential gain or loss of state income.

Wattenbarger and Bibby (1981) traced the history of the changing state role in the funding of community college operations. They discovered that the median percentage of operating budgets derived from state sources increased from 3 percent in 1929 to 51 percent in 1968 to 66 percent in 1980. For the same three years, local support decreased from 46 percent to 21 percent to 7 percent, respectively, and student fees decreased from 49 percent to 21 percent to 17 percent, respectively. Currently, the most significant source of community college income is state appropriations.

Most states allocate funds to community colleges on the basis of "enrollment-driven" formulas, i.e., funds are distributed in approximate proportion to the number of students each institution serves. State allocation formulas vary widely in complexity. Some states provide a fixed amount per student, with no consideration of varying costs among programs, whereas other states differentiate among programs and apply a cost-based program funding formula (Wattenbarger & Bibby, 1981). Among those states that utilize cost-based program formulas, there is significant variation in the number of differentiated programs.

Among those states that utilize enrollment-driven funding formulas, a variety of methods are used to measure enrollment. Many states use the number of "full-time equivalent" (FTE) students as an enrollment measure.

Other states use the number of students in average daily attendance (ADA), the number of students in average daily membership (ADM), or a simple headcount measure. Each of these, in turn, may be defined as an aggregation of smaller units such as student credits (SC) or student contact hours (SCH) (Wattenbarger & Starnes, 1976). The smallest such units that are aggregated into measures of student load are, for the purpose of this study, called <u>funding units</u>.

In this study, funding units, i.e., the smallest units that are aggregated into a measure of student load, are considered to be the "products" of a community college. They are "sold" to the state (and to the students) in return for revenue. The instructional "workforce" consists of the faculty and can be measured by the number of full-time equivalent faculty (FTEF). <u>Productivity</u> is the number of funding units produced per member of the workforce. At a community college, productivity (P) may be given by a <u>productivity formula</u> of the form

$$P = \frac{FU}{FTEF} ,$$

where FU is the number of funding units produced and FTEF is the number of full-time equivalent faculty.

Since the numerator in the productivity formula is directly proportional to state income and the denominator represents the major source of instructional cost (faculty salaries), productivity may serve as a measure of cost-effectiveness, the ratio of income to cost. Instructional areas that achieve high productivity are, in a sense, more cost-effective than those that achieve low productivity. But differences in productivity among instructional areas are often necessary due to differing pedagogical demands. Instructional areas that require small classes (and thus low enrollment per FTEF) tend to achieve low productivity. States that apply

cost-based program funding formulas recognize the natural cost differences that occur among instructional areas and provide variable rates of funding commensurate with the variable rates of cost.

Productivity can be computed for almost any level of aggregation, i.e., for a college, a campus, a department, a group of courses, a course, a single class, a group of instructors, or a single instructor. Productivity and the determination of a full-time faculty workload are the components of an academic accounting system.

Purpose of the Study

The purpose of this study was to develop and apply an academic accounting model that can be utilized as a management tool by academic administrators in community colleges. The model has two components: (a) a faculty workload model and (b) a productivity model. The academic accounting model provides a structure which can be used by academic administrators to address questions within two categories: (a) questions related to faculty workload and (b) questions related to productivity. Specific answers to such questions depend, to a great extent, on institutional priorities and management procedures. These questions are

1. Questions related to faculty workload:
    a. What is the institutional reference standard for a full faculty workload?
    b. What teaching tasks do faculty members perform?
    c. What non-teaching tasks do faculty members perform?
    d. What tasks are consistent with the college's mission?
    e. How much time per academic term do faculty members spend at each of their tasks?

f. What are the alternative methods that can be used to compensate faculty members for performing each of their tasks?

g. What is the economic impact on the institution of a change in the nature of faculty tasks?

h. What is the economic impact on the institution of providing released time to faculty for management and other non-teaching tasks?

i. How should an FTEF be defined in order to be a meaningful element in the development of a productivity model?

j. How can the institution achieve "equity" in determining a full-time load?

2. Questions related to productivity:

a. What is the predominant funding unit, if any?

b. What should be the specific form of the productivity model?

c. Can productivity represent a measure of cost-effectiveness?

d. What is the relationship between productivity and class size?

e. How is productivity at one level of aggregation related to productivities at other levels?

f. What level of productivity is necessary to maintain financial stability?

g. Does productivity only provide feedback data or can it be managed?

h. What are the techniques that can be used to manage productivity?

Delimitations

The scope of this study was delimited to instructional programs at community colleges. The specific enrollment measure selected for

incorporation into the productivity model was the predominant funding unit used by those states that provide financial support to community colleges on the basis of enrollment. Alternative funding units were not considered.

The development of the faculty workload model was delimited to activities of faculty in instructional areas. These include instruction and non-teaching tasks performed by the faculty. Other areas such as student services, public service and extension, library and learning resources, administration and general institutional support, and operation and maintenance of the physical plant were not considered.

Limitations

The internal validity of the academic accounting model is subject to the accuracy and completeness of the data obtained. The application of the model was limited to examples, problems and solutions, illustrations, and scenarios--no community college was requested to replace its own academic accounting system with the model developed in this study. As a measure of cost-effectiveness, the model applies only to income and costs related to instruction.

The properties derived from the productivity model were based on specific assumptions applied to faculty workload. These assumptions were made on the basis of the literature review concerning current workload practices and standards. Where these assumptions do not apply, the results of this study are not necessarily valid.

Justification for the Study

The needs of today's diverse student population are different from those of the past. This is particularly true at the community colleges, almost all of which accept students without regard to their interests or

academic preparations. In order to accommodate these new needs, community colleges have focused heavily on academic experimentation and change.

The community college mission contains two important components. These are (a) to be responsive to the changing postsecondary educational needs of the community and (b) to provide postsecondary educational opportunities to all members of the community (Lukenbill & McCabe, 1978). These aspects of the mission have been accomplished, to a large extent, by means of instructional innovations.

In a tightly controlled economic environment, the responsibility of providing innovative instructional arrangements carries the additional responsibility of insuring that such arrangements be cost-effective. Academic decisions should not be made in isolation from their economic consequences, and, ideally, the economic consequences should be able to be determined before such decisions are made. It is thus necessary to monitor academic programs through a system of managerial controls. An academic accounting system is, in fact, an important component of a managerial control system.

Academic Accounting as a Control System Component

The purpose of a managerial control system is "to make [any organizational unit] . . . operate in a more desirable way: to make it more reliable, more convenient, or more economical" (Bellman, 1964, p. 186). All control systems, from the simplest to the most sophisticated, contain four essential elements. These are (a) a performance *standard*, (b) a *sensor* that measures actual performance, (c) a *discriminator* that compares actual performance with the standard and evaluates the deviation, and (d) an *effector* that corrects the actual performance when its deviation from the standard is too large (Kast & Rosenzweig, 1979; Koontz & O'Donnell, 1978;

Petit, 1975). The academic accounting model presented in this study sets standards for faculty workload and provides for compensation when deviations, i.e., inequities, occur. The model also provides means for setting productivity standards. Actual performance, i.e., achieved productivity, can be measured by the productivity formula. Evaluation of deviations and imposition of corrective actions require managerial intervention.

Control systems that are designed to be applied before activity occurs are called feedforward systems. Those that control performance concurrent with activity are real-time systems. Those that are designed to correct deviations after they occur are feedback systems (Koontz & O'Donnell, 1976; Litterer, 1973). From a management perspective, the most effective control systems are feedforward or real-time. Time lag problems are inherent to feedback systems--the effector component may take effect too late to avoid serious damage caused by substandard performance (Koontz & O'Donnell, 1976). The academic accounting model, when applied to pedagogical decisions, is a feedforward system in the sense that it allows managers to determine the economic consequences of such decisions before the decisions are implemented.

Definitions of Terms

Academic accounting system. A system designed to define standards for faculty workload and to monitor productivity.

Control system. A managerial system that sets performance standards, measures actual performance, evaluates deviations when they occur, and corrects the deviations.

Corollary. A mathematical statement that is an immediate consequence of a definition or a previously established theorem.

Enrollment projection. A prediction of student enrollment for a future academic term or year.

Faculty workload. The accumulation of teaching and non-teaching tasks that faculty members perform.

Feedforward control system. A control system designed to control performance before activity occurs.

FTE. The number of full-time equivalent students, a measure of enrollment at a community college.

FTEF. The number of full-time equivalent faculty, a measure of workforce membership at a community college.

Funding formula. An objective procedure for allocating funds to community colleges.

Gaming. The process of assigning values to the variables of a mathematical equation so that the resulting equation is true.

Model. A descriptor of phenomena that identifies the appropriate elements and specifies the relationships that exist among the elements (Rigby, 1969).

Point system. A system of faculty loading that assigns a certain number of points to each recognized task performed by a faculty member. A full workload is the accumulation of a specified number of points.

Productivity. A measure of the number of revenue-generating units produced per member of the workforce.

Productivity target. A desired level of productivity that an enterprize must achieve in order to maintain sufficient financial stability to work toward its goals.

Released time. Time provided for faculty to perform non-teaching tasks.

SCH. The total number of student contact hours, a measure of enrollment.

Theorem. A statement, pertaining to a mathematical phenomenon, that must be proved by deductive reasoning.

Methodology

The procedures outlined below and detailed in subsequent sections include (a) a review of related literature, (b) data collection and analysis, (c) model construction, and (d) model applications.

Literature Review

The literature selected for review was related to managerial control, state funding of community colleges, and faculty workload. The literature on managerial control identified the components common to all control systems, enumerated the principles of control, and provided the theoretical basis necessary to incorporate the academic accounting model into a coherent system of managerial controls. The review of state funding practices verified that the trend toward increasing reliance of community colleges on state revenues, with less emphasis on local support, continues. The data obtained from this review also provided preliminary definitions of the funding units used by various states to determine allocations of funds to community colleges. The literature on faculty workload identified the various tasks performed by faculty, provided a reference standard for a full faculty load, and grappled with the concept of workload equity. The data obtained from this review provided the means to define the workload standard and to enumerate the categories of faculty activity in the faculty workload component of the academic accounting model presented in this study.

Data Collection and Analysis

Data were collected from officials or staff members of the state agencies responsible for community college affairs in selected states. The data were collected by means of telephone interviews. Each individual interviewed was asked to provide answers to the following questions:

1. Is enrollment a factor in determining the distribution of state funds to community colleges?

2. How is enrollment measured?

3. If various enrollment measures are calculated for different programs, which measure is predominant?

4. How significant are state funds in the total financial support of community colleges?

5. Are there any state-level provisions that define a standard workload for community college faculty?

The findings were presented in a state-by-state summary and condensed into a table.

Model Construction

The development of the academic accounting model was accomplished by following the steps required by Model Theory. These are (a) identify the elements and (b) analyze the relationships that prevail between or among the elements (Rigby, 1969).

The elements of the faculty workload model were obtained from the review of the literature. These were (a) a reference standard for a full faculty load; (b) the various teaching and non-teaching tasks that faculty perform; and (c) a point system that assigns points to faculty for the tasks performed and, based on the reference standard, defines a full faculty load

as a specified accumulation of assigned points. It was then possible to quantify FTEF in terms of points.

The elements of the productivity model were (a) the predominant funding unit used to generate state income and (b) FTEF. The specific funding unit was determined by data obtained from selected states. The productivity model was then written as a mathematical equation. The elementary properties of the productivity model were derived through a series of theorems and corollaries. Emphasis was given to the relationship between productivity and class size. Examples were provided to illustrate the theory.

Model Applications

In order to demonstrate applications of the model, additional concepts were introduced. These concepts were (a) enrollment projections, (b) subset productivities, (c) productivity targets, and (d) gaming. Necessary theorems and corollaries were proved, and a series of problems and solutions were presented to demonstrate various applications of the theory. Demonstrations of the uses of the model as a feedforward control system were given in a series of illustrations. Finally, two scenarios were presented to demonstrate how productivity can be managed. These scenarios provided step-by-step procedures that can be utilized by academic administrators to manage productivity at the department and campus levels.

CHAPTER II

A SELECTIVE REVIEW OF RELATED LITERATURE

In states that utilize enrollment-driven funding formulas, one of the essential management tools at a community college is a system that provides the capability to monitor the cost-effectiveness of instruction. The academic accounting model presented in this study is a system which monitors cost-effectiveness through the concept of productivity. Specifically, the academic accounting model relates state income generated by instruction to the major source of instructional cost. In this capacity, the academic accounting model is a component of a managerial control system and is feedforward in the sense that it can be used to forecast the economic consequences of pedagogical decisions.

According to Model Theory (Rigby, 1969), in order for the academic accounting model to serve as a valid descriptor of phenomena, it must (a) identify the elements involved and (b) describe the relationships that prevail between or among the elements. The elements of the academic accounting model are

1. A funding unit, FU, from which community colleges generate state income, and

2. The requirements and tasks that contribute to the definition of full-time equivalent faculty (FTEF). The funding unit is quantitative by definition. With a quantitative definition of FTEF, the relationship prevailing among the elements can be given in terms of a productivity formula

$$P = \frac{FU}{FTEF} .$$

The productivity formula thus provides an index of instructional cost-effectiveness that can be applied to almost any level of aggregation.

The review of literature was divided into three main categories: (a) managerial control, (b) state funding practices, and (c) faculty workload. The material on managerial control, which mainly consisted of journal articles and books on management theory, provided the basic components and applications of general managerial control systems. The literature on state funding practices provided an overview of current funding procedures, the criteria on which these procedures are based, and an identification of the various enrollment measures (funding units) used to generate state income. The data derived from the review of faculty workload provided descriptions of the various tasks that faculty members perform, provided a reference standard for a full faculty work load, and enabled a quantitative definition of FTEF to be derived.

Managerial Control

The purpose of control is "to make a system--any kind of system--operate in a more desirable way: to make it more reliable, more convenient, or more economical" (Bellman, 1964, P. 186). Litterer (1973) stated

> We are concerned with control in relation to matching performance with necessary or required conditions to obtain a purpose or objective. The essence here is on directivity and integration of effort, required accomplishment of an end. Control is concerned not only with events directly related to the accomplishment of major purposes but also with maintaining the organization in a condition in which it can function adequately to achieve these major purposes. (p. 528)

Controlling is an important aspect of management, as are planning, organizing, directing, and communicating. None of these can exist in isolation. According to Luthans (1976), "Once plans are made, the organization designed, directing takes over, and communication begins to flow, then the process of control becomes important" (p.143). Kast and

Rosenzweig (1979) embedded control into the management process by defining <u>organizational control</u> as

> That phase of the management system that monitors performance and provides feedback information that can be used in adjusting both ends and means. Given certain objectives and plans for achieving them, the control function involves measuring actual conditions, comparing them to standards and initiating feedback that can be used to coordinate organizational activity, focus it in the right direction, and facilitate the achievement of a [steady state]. (p. 466)

A theory of control emerged from the field of cybernetics and has grown "in an almost symbiotic relation" with the advancements in computer technology (Bellman, 1964, p. 186).

<u>Theoretical Foundations: Cybernetics</u>

Prior to World War II, control phenomena were studied in a wide variety of separate fields. In the early 1940s, a group of specialists from these fields, under the leadership of the mathematician Norbert Wiener, undertook a joint project to incorporate their separate findings into a single theoretical framework. Included in the group were mathematicians John von Neumann and Walter Pitts; biologists Warren McCullough and Lorente de No; psychologist Kurt Lewin; anthropologists Gregory Bateson and Margaret Mead; economist Oskar Morgenstern; physiologist Arturo Rosenbleuth; and representatives from the fields of engineering, communication, philosophy, and psychiatry (Wiener, 1968). They gave birth to <u>cybernetics</u>, the science of communication and control (Petit, 1975).

From the cybernetic viewpoint, systems can be categorized on the basis of two distinct criteria: complexity (simple, complex, or exceedingly complex) and predictability (deterministic or probabilistic). A system that has few components and behaves in a totally predictable manner is called a <u>simple deterministic system</u>. A billiard shot is an example of a simple deterministic system because a given force applied to the ball has a fully

predictable effect. A complex deterministic system has many components, can be described, and exhibits predictable behavior. An electronic computer and the solar system are complex deterministic systems. An exceedingly complex deterministic system has too many components to describe fully but operates in a predictable manner. There are no known examples of such a system. A simple probabilistic system has few components and behaves with uncertainty. Coin tossing is an example. Examples of complex probabilistic systems are conditioned reflexes in animals and industrial profitability. The nation's economy, the human brain, and a business enterprise are regarded as exceedingly complex probabilistic systems. They are so complex and so uncertain that they defy complete description (Beer, 1967).

A cybernetic system is one which achieves self-regulation by means of messages that the system sends to itself. In any open system, inputs are received from the environment, the inputs are processed to produce outputs, and the outputs are exported back to the environment. Part of the output is information, fed back to the system by the system itself, about how well the system is functioning. This information, or feedback, is relayed to the input stage and inputs are adjusted accordingly. The flow of information makes self-regulation possible. Thus, a cybernetic system is a system in which inputs affect outputs and outputs adjust inputs (Petit, 1975).

Essential Components of Control Systems

All control systems, from the simplest to the most sophisticated, contain four essential elements: (a) a measurable and controllable phenomenon or characteristic for which standards are predetermined, (b) a sensory device or sensor that measures that actual performance of the phenomenon being controlled, (c) a comparator or discriminator that compares the actual performance with the standard and evaluates the deviation, and

(d) an action unit or effector that corrects the actual performance when its deviation from the standard is too large (Kast and Rosenzweig, 1979; Koontz and O'Donnell, 1978; Petit, 1975). The maintenance of an effective control system depends heavily on the flow of information at each stage of the control process (Kast and Rosenzweig, 1979).

The thermostat

The classical illustration of a control system is the thermostat which activates and deactiviates a furnace used to heat a house. The characteristic to be controlled is the temperature of the room in which the thermostat is located. The predetermined standard is the temperature setting. The sensor is a thermometer that measures the actual room temperature. The discriminator compares the actual temperature to the standard. The effector responds to the discriminator by deactivating or activating the furnace when the actual temperature deviates too far, say plus or minus three degrees, from the standard. The flow of information is conducted through the wiring system (Lawler, 1979; Litterer, 1973).

Types of standards

The establishment of standards in an organization is an integral part of the planning process. The purpose of establishing standards is to define outcomes. This "attempt to predict future events provides the basis for interpreting the meaning of events when they actually occur" (Massie, 1979, p.91). Without standards, a control system cannot function. However, just as the thermostat is not equipped to evaluate the appropriateness of a temperature setting, a useful managerial control system need not evaluate the appropriateness of standards; it merely provides a means through which organizational activity can be directed toward their accomplishment (Massie,

1979). According to Luthans (1976), standards are of two types: quantitative and qualitative.

Quantitative standards. The quantitative aspects of an organization are those which lend themselves to numerical measurement. In industrial organizations, labor costs per unit of production, ratios of current assets to current liabilities, units of production per machine hour, sales per capita in a given market area, and return on investment are examples of quantitative standards (Koontz & O'Donnell, 1978). In educational institutions, average class size, administrative costs per student, attrition rates, the number of students per square foot of classroom space, the number of library volumes per student, and student-faculty ratios are examples of quantitative standards.

Qualitative standards. Qualitative standards came to be regarded as essential to the success of organizations when administrative theory moved toward an emphasis on human relations. Organizational image, employee job satisfaction, and motivation are examples of qualitative standards. Devices through which qualitative standards can be controlled include (a) participative budgeting, (b) diagnostic rather than punitive evaluative techniques, (c) executive performance appraisal programs, and (d) devices to measure employee attitudes (Luthans, 1976).

Types of sensory devices

The process of measuring actual performance requires the greatest attention and expense of all the components of the control system (Massie, 1979). It is the information-gathering phase of the control process. Luthans (1976) identified the most common procedures used by organizations to measure actual performance as personal observation, gathering statistical data, preparing oral and/or written reports, and accounting. Despite the

subjective nature of personal observation, it is the simplest measurement procedure and is commonplace in organizational control system. Statistical data provide objective measures of performance, but an overemphasis on objectivity can distort organizational goals (Miner, 1978). Oral reports provide quick feedback on the basis of which immediate corrective action can be taken. Organizations rely heavily on written reports to measure performance. Luthans (1976) posited that written reports have been misused and overused to the detriment of organizational efficiency. He suggested that "every form of report should be put on trial for its life every five years instead of being allowed to continue indefinitely" (p.149). The accounting process is used to measure financial performance and, through its linkage to the management information system, generates information for managerial decision making.

Comparison methods

The process of comparing the measured organizational performance with the predetermined standards requires the intellectual participation of management. Some deviation from the standard is to be expected. The manager must be able to determine clearly the acceptable limits on variance (Massie, 1979). All performance data must be examined in light of existing circumstances. Performance that is measured quantitatively can usually be compared to standards by means of charts and graphs. Judgments concerning qualitative aspects require good managerial instinct and a knowledge of past organizational performance.

Types of corrective actions

When actual performance has been found to deviate unacceptably from the predetermined standard, managers may act to correct the deviation. According to Miner (1978), the most common type of corrective action

involves an application of authority in order to motivate a change in employee behavior. Additional corrective actions include personnel reassignment, clarification of duties, additional staffing, better selection and training of employees, or termination of personnel (Koontz & O'Donnell, 1976). Managers can also correct deviations by providing more effective leadership or by simply revising the standard (Miner, 1978).

<u>Prerequisites of control systems</u>

According to Koontz and O'Donnell (1976), two major prerequisites are essential to the implementation and maintenance of a control system: plans and an organizational structure. Plans determine the standards on which the control system is based. Controls can be effective only if plans are clear, complete, and integrated. An organizational structure is essential because it defines precisely where the responsibilities for deviating from standards and for taking corrective action occur. Controls can be effective only if the organizational structure is clear, complete, and integrated.

<u>Control System Models</u>

Two types of models are used to describe control systems: the <u>closed-loop system</u> and the <u>open-loop system</u>. The feature that differentiates them is the existence of a device that automatically triggers corrective action when a deviation occurs (Miner, 1978).

<u>Closed-loop systems</u>. A closed-loop system reacts automatically to correct deviations. The thermostat and the various industrial computer-based control systems are examples. This type of control system operates without a human diagnostic step. No human intervention is needed to determine what appropriate corrective action should be taken when deviations occur (Miner, 1978).

Open-loop systems. An open-loop control system is one in which the occurrence of deviations does not automatically trigger corrective action. An external device, usually a human, must intervene to provide a diagnosis and made a decision concerning corrective steps (Miner, 1978).

Kast and Rosenzweig (1979) maintained that control systems exist on a continuum from relatively closed-loop to relatively open-loop. The thermostat, for example, is reset occasionally. In organizations that require frequent human diagnosis, the existence of habits and standard operating procedures tends to close the control system.

Objects of Control

Each unit of an organization has critical areas that need to be controlled. At the operations level, the vital targets of control are quantity, quality, time use, and cost (Luthans, 1976). The purpose of quantity control is to coordinate production with perceived demand. Quality control insures that inputs and outputs are consistent with predetermined specifications. Time use control is generally associated with work scheduling, but also applies to the efficient scheduling of managerial activities. Cost control is used to specify where dollars are expended. _Direct costs_ are those that can be specifically identified with a product, i.e., costs for labor and materials or the cost per product. _Indirect costs_ are overhead expenditures that are not specifically related to products (Kast & Rosenzweig, 1979; Luthans, 1976).

Jerome (1975) classified control systems according to their objects. These were

1. Controls used to standardize performance in order to increase efficiency and lower costs.

2. Controls used to safeguard organizational assets from theft, wastage, or misuse.

3. Controls used to standardize quality.

4. Controls designed to set limits within which delegated authority can be exercised without prior top management approval.

5. Controls used to measure on-the-job performance.

6. Controls used for planning and programming operations.

7. Controls necessary to allow top management to keep the organization's various plans and programs in balance.

8. Controls designed to motivate individuals within the organization to contribute their best efforts.

Timing and Control

Control systems can be classified on the basis of the time relationship that exists between the controlling effort and the occurrence of the activity being controlled. Those which are designed to impose controls prior to activity are called precontrol or feedforward systems. Those which control performance while activity takes place are called current or real-time systems. Postcontrol or feedback systems are those in which corrections of deviations are applied after activity occurs (Koontz and O'Donnell, 1976; Litterer, 1973). Effective feedforward and real-time controls can help eliminate the time lag problems inherent to feedback systems that may "tell [administrators] in November that they lost money in October (or even September) because of something that happened in July" (Koontz & O'Donnell, 1976, p.646).

Feedforward systems

Simply stated, a feedforward system is a control system applied to inputs instead of outputs. A feedforward system utilizes forecasts instead

of historical data; however, historical data can be utilized to generate valid forecasts. If organizational inputs are not as planned, then these inputs, or the designed activity, are changed to assure the achievement of the desired results (Koontz & O'Donnell, 1976).

Examples of feedforward systems are preventative maintenance programs, all forms of policies, input checklists, and network analysis. Preventative maintenance is applied to the critical parts of a machine in order to prevent malfunction or breakdown. Policies are formulated to help prevent potential problems and misunderstandings. Input checklists are designed to insure that all essential physical inputs are present and in good working order. Network analysis is a planning tool that partitions a major project into a sequence of events (Luthans, 1976). Feedforward systems establish guidelines for future performance that are consistent with organizational plans.

Real-time systems

Real-time control is possible only if immediate feedback on performance can be obtained while the activity takes place. It is often preferable to adjust behavior in small increments while it occurs rather than wait until the activity is completed before initiating corrective action. With a real-time system in place, performance can be adjusted before it deviates too far from the prescribed standard (Kast & Rosenzweig, 1979). In an organization, the responsibility for implementing real-time control systems is most likely to rest near the bottom of the managerial hierarchy since managers at this level are best situated to deal with immediate problems (Litterer, 1973).

Direct Versus Indirect Control

According to Koontz and O'Donnell (1978), there are two strategies which can be applied to insure that the performance of units or people within an organization conforms to preassigned standards. One strategy is to trace the cause of an undesirable result to those responsible and impose a change in practices. This is indirect control. The alternative is to develop skillful managers who perform their tasks on the basis of sound management principles and are thus able to avoid those deviations that are generally caused by poor management practices. This is direct control.

Indirect control can be expensive and time-consuming. Moreover, the effectiveness of indirect control rests on five questionable assumptions. These are

1. Performance can be measured.

2. Responsibility for performance can be attributed to a unit or person.

3. The necessary time expenditure for indirect control is warranted.

4. Mistakes can be anticipated or discovered before serious deviations occur.

5. The unit or person responsible for deviations will take the required corrective steps (Koontz & O'Donnell, 1978).

The objective of direct control is to be able to determine whether or not managers act in accordance with established management principles. The function of a principle is "to reflect or explain reality, and therefore to have value in predicting what will happen in similar circumstances" (Koontz & O'Donnell, 1978, p.8). Direct control can be attained by two methods: (a) management appraisal and (b) management audit. Management appraisal is an evaluation of individual managers whereas a management audit investigates

the organization's management system wholistically (Koontz & O'Donnell, 1978).

Control Principles

Some authors (Petit, 1975; Jerome, 1975) have insisted that the nature of a control system is dictated by the nature of the specific organization and, accordingly, no set of control principles could be developed and applied to organizations abstractly. Koontz and O'Donnell (1976) posited that this was not the case. They derived thirteen principles of control that apply to any organization regardless of its nature. Their principles were grouped into three categories:

1. Principles of purpose and nature.
2 Principles of structure.
3. Principles of process.

The principles of the purpose and nature of controls are

1. Principle of assurance of objective. The task of control is to assure that plans succeed by detecting deviations for plans and furnishing a basis for taking action to correct potential or actual deviation.

2. Principle of future-directed controls. Because of time lags in the total system of control, the more a control system is based on feedforward rather than simple feedback of information, the more managers have the opportunity of perceiving undesirable deviation from plans before they occur and of taking action in time to prevent them.

3. Principle of control responsibility. The primary responsibility for the exercise of control rests in the manager charged with the performance of the particular plans involved.

4. Principle of efficiency of controls. Control techniques and approaches are efficient if they detect and illuminate the nature and causes of deviations from plans with a minimum of costs or other unsought consequences.

5. Principle of direct control. The higher the quality of every manager in a managerial system, the less will be the need for indirect controls. (pp. 736-737)

The principles of structure indicate how control systems should be designed in order to improve the quality of managerial control. They are

1. <u>Principle of reflection of plans</u>. The more that plans are clear, complete, and integrated, and the more that controls are designed to reflect such plans, the more effectively controls will serve the needs of managers.

2. <u>Principle of organizational suitability</u>. The more that an organizational structure is clear, complete, and integrated, and the more that controls are designed to reflect the place in the organizational structure where responsibility for action lies, the more they will facilitate correction of deviations from plans.

3. <u>Principle of individuality of controls</u>. The more that control techniques and information are understandable to individual managers who must utilize them for results, the more they will actually be used and the more they will result in effective controls. (pp. 737-738)

Principles that apply to the process of control are

1. <u>Principle of standards</u>. Effective control requires objective, accurate, and suitable standards.

2. <u>Principle of critical-point control</u>. Effective control requires attention to those factors critical to appraising performance against an individual plan.

3. <u>The exception principle</u>. The more managers concentrate control efforts on exception, the more efficient will be the results of their control. . . . Managers should concern themselves only with significant deviations.

4. <u>Principle of flexibility of controls</u>. If controls are to remain effective despite failure or unforeseen changes of plans, flexibility is required in their design. . . . Controls must not be so inflexibly tied in with plans as to be useless if the entire plan fails or is suddenly changed.

5. <u>Principle of action</u>. Control is justified only if indicated or experienced deviations from plans are corrected through appropriate planning, organizing, staffing, and directing. (pp. 738-739)

<u>Dysfunctional Consequences of Control Systems</u>

Instead of, or in addition to, controlling organizational activity as intended, control systems can produce undesirable side effects. Such dysfunctional consequences usually result from negative reactions of

organizational members to control systems. Five dysfunctional consequences have been identified (Lawler, 1976; Longenecker, 1977). They are

1. Rigid bureaucratic behavior.
2. Resistance to control systems.
3. Production of invalid data.
4. Narrow viewpoint.
5. Premium on short-term results.

Bureaucratic behavior consists of individuals behaving in ways that are dictated by the control system but are dysfunctional in that such behavior may prevent the organization from accomplishing its major goals. If the control system is not sufficiently inclusive, the standards are set too high, the reward system is too closely tied to the control system, or the organizational goals are not clear, then rigid bureaucratic behavior may result (Lawler, 1976).

Resistance to control systems occurs when they are perceived as a threat to the need satisfaction of employees. Such resistance is likely when the control system measures performance in a new area, the control system replaces one that has high acceptance, or standards are set without participation (Lawler, 1976).

Control systems can result in the production of two kinds of invalid data: (a) data relative to what has been done and (b) data relative to what can be done. Data are more likely to be distorted if they are subjective, difficult to verify, or likely to reflect on the competence of the individual producing them (Lawler, 1976).

A narrow viewpoint and an emphasis on short-term results are potential side effects of control systems. They are likely to occur when broad

organizational goals are not clearly communicated or when a high level of subunit identification exists (Lawler, 1976; Longenecker, 1977).

Summary

In any organization, the purposes of a control system are (a) to set standards of performance, (b) to measure actual performance, (c) to compare actual performance with the standard, and (d) to correct actual performance when it deviates too far from the standard. The academic accounting model presented in this study provides a structure with which community college academic administrators can establish control systems in two areas of performance. These are (a) faculty workload and (b) productivity of instructional areas.

According to the literature, control systems are most effective when they (a) are feedforward in nature, (b) are implemented by high quality managers, (c) adhere to basic control principles, and (d) avoid dysfunctional consequences. These criteria underlie the effective application of the academic accounting model.

State Funding of Community Colleges

As late as 1929, Texas statutes prohibited the use of state funds to support community colleges (Wattenbarger & Cage, 1974). At that time, the median amount of state support received by community colleges in all states was only 3 percent of total revenue. The major portion of income was derived from local sources (46 percent) and student fees (49 percent). By contrast, the median level of state support for community colleges in 1980 was 66 percent whereas local support and student fees accounted for 7 percent and 17 percent, respectively, of total revenue (Wattenbarger & Bibby, 1981). The trend toward increasing reliance on state support of community colleges, with less emphasis on local sources and student fees,

has been verified by several authors (Medsker, 1960; Thornton, 1966; Lombardi, 1973; Wattenbarger & Stepp, 1979; Breneman & Nelson, 1981).

Philosophical Underpinning for Increased State Support

The state's role in financing higher education arises from the increased awareness that the responsibility for providing postsecondary education rests with the public and from various human capital studies which provided evidence that societal investments in higher education are worth the cost. Bowen (1977), on the basis of his review of studies concerning the benefits of higher education, estimated that the societal benefits exceed the cost by at least a factor of three. He posited that

> The monetary returns alone, in the form of enhanced earnings of workers and improved technology, are probably sufficient to offset all the costs. But over and above the monetary returns are the personal development and life enrichment of millions of people, the preservation of the cultural heritage, the advancement of knowledge and the arts, a major contribution to national prestige and power, and the direct satisfactions derived from college attendance and from living in a society where knowledge and the arts flourish. (p.447)

Cohn (1974) stated that

> It has been recognized that whatever externalities that higher education creates are likely to spread over wider geographical region than is the case for elementary and secondary education. Therefore, there is a stronger case for involving higher levels of government [than only local levels,] such as the state and federal agencies in the . . . support of higher education. (p. 134)

The National Commission on Financing Postsecondary Education (NCFPE) reported that the fifty states have shared a number of objectives in meeting their responsibilities for support of postsecondary education (Evans, 1973). With respect to the support of community colleges, all states seek to provide

1. Maximum postsecondary educational opportunities for their citizens according to the financial resources available to

> states and the attitudes of their citizens regarding government's responsibility for providing such opportunity, . . ., and
>
> 2. Training in professional technical occupations believed to be important to the economic development of each state and the welfare of its citizens. (p. 82)

Boyer (1973), a member of the NCFPE, added two more objectives for states to consider. These are

> 1. State and local governments have the primary responsibility of providing basic institutional aid to postsecondary education, . . . , and
>
> 2. Public institutions, as a general rule, should receive their primary institutional support from state and local governments. Such support should be adequate to maintain an excellent and diversified network of two-year, baccalaureate, and graduate institutions in each state. State and local support should be sufficient to make it possible for public institutions to provide two years of postsecondary education to all qualified students, preferably at no cost to the student, but at least at tuition rates not exceeding present levels. (p. 362)

State and local burdens

According to Bender (1973), the federal involvement in community college support has essentially been limited to a student-centered role that provides financial assistance to help defray student expenses. The major burden of governmental support of the institutions themselves has been left to state and local levels. Martorana, Wattenbarger, and Smutz (1978) provided three reasons why the majority of the state and local burden has, in fact, been assigned to the state. These are (a) the inability or unwillingness of local residents to increase appropriations in order to sustain such multi-missioned institutions, (b) the relative inelasticity of the property tax, and (c) a commitment by several state legislatures to provide postsecondary educational opportunities for their citizens. The NCFPE report indicated that

> In general, . . . the local responsibility for operating and financing two-year colleges appears to be declining as a result of increasing opposition to heavy reliance on local property taxes . . . and growing state interest in improving statewide coordination and planning. (Evans, 1973, p. 84)

Brossman (1974) favored the decrease in the financial burden on local taxpayers together with "increases in support from state and federal sources" (p.31).

Medsker (1971) presented three arguments for increased reliance on state support of community colleges. These were

> 1. [Increased state support] tends to equalize the burden of . . . support.
>
> 2. [Increased state support] draws on funds from sources other than property taxes.
>
> 3. [Increased state support] places the funding . . . on somewhat the same footing as other public higher education. (p.145)

According to Wattenbarger, Holcombe, Myrick, and Paulson (1973), increased state support of community colleges is necessary for these institutions to fulfill their mission of enhancing educational opportunity. They posited that local sources of tax revenue are not sufficient to

> 1. Meet the demands of increasing enrollment, especially where a large percentage of the population continues education.
>
> 2. Meet the demands for increasing services, especially when the door is truly open to "new" students having a wider range of abilities and ages.
>
> 3. Meet the demands for comprehensive programming, which includes a variety of courses and programs to satisfy the diversity of students.
>
> 4. Eliminate the barriers to continued education such as geography, age level, and the inability of some districts to support necessary programs. (p. 14)

State and student burden

The question of state-versus-student sharing in the cost of higher education is one that is addressed in the debate concerning high or low

tuition. The position taken by proponents of cost-reflective tuition was summarized by Halstead (1974). Low tuition levels, they argue, force poor families to subsidize the education of high income students through taxation. Low tuition is thus regressive. High tuition advocates would prefer that colleges charge full-cost tuition and that a federally sponsored program target generous financial aid to needy students. The effects of this arrangement would be

1. To make tuition more progressive by placing the burden on those who can afford it;

2. To expand educational opportunity for needy students through the financial aid provision;

3. To increase student choice, because financial aid would be available to students attending either public or private colleges; and

4. To increase the quality of educational programs by enhancing the competition between public and private colleges.

At the heart of the tuition debate is the assumption that the cost of higher education should be borne by the beneficiaries in proportion to the benefits received. According to Chambers (1968), "private gains are far outweighed by the gains that concurrently accrue to the whole society" (p. 91). He thus posited that the major responsibility for the support of higher education should rest with the taxpayers.

Finn (1978) argued that a full-cost tuition policy clashes with a basic tenet of public higher education--the belief that access to colleges and universities should be available to all who can benefit. He posited that high tuition stands as an artificial, possibly insurmountable, barrier to prospective students and their families. An analysis of demand for higher education, conducted by McMahon (1974), provided evidence that

> Finally, it is clear that maintaining low tuition policies at public institutions makes higher education available to a larger fraction of the population as incomes rise and demands increase. (p. 72)

In summarizing the findings of a study conducted by NCFPE, Lawrence (1974) stated

> Increases in the effective price (tuition minus student aid) of postsecondary education--the price the student must pay--result in decreases in enrollment; conversely, decreases in the effective price result in increases in enrollment. (p. 26)

Funding Criteria

Several authors (Arney, 1969; Wattenbarger and Cage, 1974; Starnes, 1975; Garms, 1977; Martorana and Wattenbarger, 1978) have developed criteria for state financial support of community colleges. In particular, those suggested by Martorana and Wattenbarger provide an operational framework within which state funding practices can be evaluated. They maintained that state funding procedures should

1. Be consistent with the characteristic community college goals of open access, comprehensiveness, and sufficient local control to assure responsiveness to local needs;

2. Leave academic policy prerogatives in the hands of local administration;

3. Be objective in determining the weights assigned to the various factors included in the funding plan;

4. Protect minimum levels of quality of programs and services offered;

5. Allow local authorities flexibility in the administration of approved budgets;

6. Insure inter-district equity of tax burdens. This criterion applies to states that require local participation in the financial support of community colleges; and

7. Provide adequate, but not stifling, procedures for accountability between community colleges and their major sources of financial support.

Patterns of State Support

Although each of the states has adopted its own unique procedure for financing community colleges, attempts have been made to provide taxonomies of procedures based on some common characteristics. Augenblick (1978) analyzed the various funding arrangements and concluded that state allocation of funds to community colleges may take the form of a flat grant, a minimum foundation grant, a percentage equalizing grant, or a proportion of expenditures with a flat grant ceiling. Some states allow for differential costs on the basis of institutional, program, or student characteristics.

Starnes (1975) developed four models to describe common characteristics of state funding practices. These are (a) negotiated budget funding, (b) formula unit funding, (c) minimum foundation funding, and (d) cost-based program funding.

Negotiated budget funding. State community college funding that must be negotiated between the legislature or a state board and college representatives is called negotiated budget funding. College budgets may require approval either as a single entity or by line item. In general, allocations are not formula-based. Although negotiated budget funding procedures feature a high degree of accountability, local autonomy may be eroded (Starnes, 1975).

Formula unit funding. A procedure that allocates state funds to community colleges on the basis of a simple formula specifying a fixed number of dollars per funding unit is a formula unit funding procedure.

Formula unit funding is also referred to as a flat grant procedure (Augenblick, 1978; National Education Finance Project, 1971). In general, this procedure ignores cost differences that may exist among the various programs of instruction (Starnes, 1975).

<u>Minimum foundation funding</u>. Minimum foundation or equalization funding is a procedure whereby the state allocation to community college districts is in approximate inverse proportion to district property wealth. In general, the state prescribes a minimum millage levy and guarantees a minimum level of support per funding unit when state and local funds are combined (Starnes, 1975).

<u>Cost-based program funding</u>. The allocation of state funds on the basis of multiple cost centers, detailed instructional discipline categories, program functions, or budgeted objects of expenditure in combination with a funding unit is considered to be cost-based program funding. Differentiation for costs of instructional programs may be made between academic transfer courses and vocational/technical courses or among several identified disciplines. Cost differences among the separate funding categories are most commonly established by detailed cost studies (Starnes, 1975).

Each of the four models developed by Starnes--negotiated budget funding, formula unit funding, minimum foundation funding, and cost-based program funding--was investigated by Martorana and Wattenbarger (1978) and evaluated on the basis of how well it satisfied their funding criteria. Table 1 provides a summary of their findings. Overall, cost-based funding programs perform best within the framework of the criteria whereas negotiated budget programs perform the worst.

Table 1
Evaluation of State Procedures to
Finance Community Colleges[a]

Evaluation Criteria	Negotiated Budget	Unit-rate Formula	Minimum Foundation	Cost-based Funding
1. Consistency with Community College Goals				
A. Open Access	1	3	4	3
B. Comprehensiveness	1	2	4	5
C. Local Control	1	5	4	3
2. Local Policy Prerogatives	1	5	4	4
3. Funding Objectivity	1	4	4	5
4. Protection of Quality	2	1	1	3
5. Local Budget Flexibility	1	5	4	4
6. Equity of Tax Burden	5	3	5	4
7. Accountability				
A. To State	5	1	3	5
B. To District	1	4	3	4
Cumulative Index	19	33	36	40

[a]Key: 5 = Strong

4 = Strong to Moderate

3 = Moderate

2 = Moderate to Weak

1 = Weak

Source: Martorana & Wattenbarger (1978).

Formula Funding

In order to minimize subjectivity in the allocation of funds to community colleges, most states have developed funding formulas. Miller (1964) defined a formula as

> An objective procedure for estimating the future budgetary requirements of a college . . . through the manipulation of objective (quantitative) data about future programs and the relationship between programs and costs, in such a way as to derive an estimate of future costs. (p.6)

According to Halstead (1974), funding formulas and institutional cost analysis are closely related. He stated that

> Cost analysis measures the current cost of various units of existing programs; formulas extrapolate these cost relationships (with necessary quality and price adjustments) so that, given the expected levels of operation, the cost of future programs can be estimated. (p. 661)

Cost analysis data, therefore, provide assistance in explaining and justifying the budgetary demands of community college programs. Funding formulas extend these data to project future program needs and to allocate resources throughout the state system.

Formula funding units

Halstead (1974) posited that a state funding formula, if it is to serve as a reliable allocation tool, must meet the criterion of quantitative definability, i.e., that

> Insofar as practical, formulas . . . should be expressed in measurable terms (subject to physical count) to avoid the bias, errors of judgment, and differences of opinion normally encountered in subjectively derived values. . . . A corollary criterion is that formula [funding] units be defined so as to take advantage of readily available data. (p. 663)

According to Hyde and Augenblick (1980), most state formulas are based on the number of full-time equivalent (FTE) students enrolled, or projected to be enrolled. In those states that apply such enrollment-driven formulas, allocations are determined by a measure of student load. Various studies

(Wattenbarger & Cage, 1974; Wattenbarger & Starnes, 1976; Augenblick, 1978; Wattenbarger & Bibby, 1981) have shown that definitions of student load measures, e.g., the FTE, vary among the states.

Wattenbarger and Starnes (1976) presented definitions of FTE as given in 31 states, 25 of which allocate funds on the basis of enrollment-driven formulas. Although there was significant variation in these definitions, the overwhelming majority of states defined one FTE to be an aggregation of either student credits or student contact hours. One annual FTE is defined to be an aggregation of either 30 semester credits or 45 quarter credits in Arizona, Arkansas, Florida, Hawaii, Illinois, Kansas, Minnesota, Montana, New Jersey, New York, Ohio, Oklahoma, Oregon, South Carolina, Tennessee, Washington, and West Virginia. An FTE is an aggregation of 50 quarter credits in Georgia, 36 quarter credits in Alabama, and 24 semester credits in Wyoming. In California, an FTE is an aggregation of 525 student contact hours. In Wisconsin, an FTE is an aggregation of 30 semester credits for credit courses or 810 student contact hours for non-credit courses. Although no definition of FTE was provided for Texas, funds in that state are allocated on the basis of student contact hours.

In most states, funding units are of two types--student credits or student contact hours. From an economic standpoint, either of these may be considered to be the product of a community college, i.e., what is "sold" to the state in return for income. In the industrial setting, corporations must maintain a certain amount of production per member of the workforce, i.e., a certain productivity, to ensure financial stability. Community colleges must similarly generate a certain number of funding units per full-time faculty member in order to generate sufficient income to deliver programs effectively. Central to the issue of productivity is the

determination of the types of activities that constitute a definition of faculty workload.

Faculty Workload

In its broadest sense, faculty workload is "the sum of all activities which take the time of a college . . . teacher and which are related either directly or indirectly to his [/her] professional duties, responsibilities, and interest" (Stickler, 1960, p. 80). In addition to conducting classes and laboratories, faculty workload may include such activities as preparation of lessons; designing and correcting examinations; advising students; selecting texts, library books, and audiovisual materials; revising courses; membership on college committees; attendance at meetings; research; and sponsorship of student groups (Lombardi, 1974).

Higher education has always been and continues to be a labor-intensive enterprise. Faculty salaries constitute 60 to 80 percent of the cost of operating an institution (Swofford, 1978). The public, through its legislative representatives, is demanding that faculty members be held accountable for their time. According to Rommey (1971),

> The public's willingness to support higher education is becoming increasingly conditional. Clearly, the education enterprise is subject to increasing scrutiny. Concomitantly, interest in what faculty do increases because faculty are particularly visible and because they constitute the major institutional cost. (p. 1)

Evidence that state legislators have been giving increased attention to the issue of faculty workload in the public colleges and universities was provided in a study conducted by Henard (1979). In that study of 40 states, utilizing the executive officers of the state commissions or state boards of higher education as respondents, 24 of the respondents expressed the opinion that "faculty workload will be an issue raised by state legislative or executive committees in the 1980s" (p. 3). Nineteen of the respondents

indicated that postsecondary institutions in their states are required to report faculty workload statistics and an additional 16 respondents indicated that such a requirement was being considered. Moreover, in 27 states, faculty workload is a consideration in either state appropriations or allocation of full-time equivalent faculty (FTEF) to postsecondary institutions. Henard attributed the increased legislative interest in faculty workload to the drive for cost containment and to legislators' beliefs that faculty members do not spend enough time with students. Henard posited that postsecondary institutions may be forced to devote more attention to the development of expertise in determining faculty workload.

Components of Faculty Workload

To define faculty workload in terms of weekly teaching hours does not appear to be a realistic approach to the workload issue. In a study conducted by Baldridge, Curtis, Edker, and Riley (1978), it was shown that teaching and teaching-related activities accounted for 70 percent of two-year college faculty time, 50 percent of four-year college faculty time, and one-third of faculty time at doctorate-granting institutions. According to Committee C of the American Association of University Professors (AAUP),

> In the American system of higher education, faculty "workloads" are usually described in hours per week of formal class meetings. As a measurement, this leaves much to be desired. It fails to consider other time-consuming institutional duties of the faculty member, and even in terms of his [/her] teaching it misrepresents the true situation. The teacher normally spends far less time in the classroom than in preparation, conferences, grading of papers and examinations, and supervision of remedial or advanced student work. (Megaw, 1968, p. 256)

The consensus of authors is that a definition of faculty workload must include components in addition to weekly teaching hours. Douglas, Krause, and Winogora (1980) identified the components of faculty workload as teaching, scholarly research, internal institutional service, and community

public service. Workload components identified by Bolton (1965) were contact hours in the classroom, student advisees, committee memberships, administrative duties, and service activities. Swofford (1978) posited that the determination of faculty workload must include, but not necessarily be limited to, such factors as teaching, committee membership, scholarly research, public relations activities, community service, professional improvement, student advisement, sponsorship of student organizations, previous work overloads, and previous work underloads. He stated that "so far there has been little reported success in establishing quantitative norms for such a variety of activities . . . [and] there have been few reported attempts to do so" (p. 53).

In addition to identifying the components or activities associated with faculty workload, there remains the issue of determining the relative weight or value to be assigned each activity as a portion of total workload. According to Romney (1971),

> Quite apart from technical problems of clearly identifying patterns of faculty activity and output are the problems of attaching values to these patterns. Are teaching activities more "valuable" than . . . [other] activities associated with . . . [professional service]? Regardless of the answer, is the same relative "value" to be attached to the activities of every situation? (p. 2)

At the Sixth Annual Conference of the National Center for the Study of Collective Bargaining in Higher Education, Sobel (1978) raised a number of questions to be considered by administrators and faculty in their efforts to quantify workload. These were

1. What is the normal teaching load in terms of hours? These must frequently be specified by College, Department, and Program; and, in a multi-university setting, by Campus.

2. What allowance must be made for class size and numbers of preparations, especially in the context of large lecture sections, and the administration of multisection courses?

3. How are such entities as practicums, laboratories, special experimental courses, team teaching, graduate seminars, directed individual studies, play direction, concerts, orchestral, choir or band direction, etc., to be treated for purposes of calculating load?

4. What treatment should be accorded advising, participation on school committees, and research in reducing teaching load?

5. Should an overload in a given semester be allowed to counterbalance an underload in a previous period, or should overload always receive extra compensation? Can a faculty member underloaded on one campus of a multi-campus unit be required to compensate by teaching on an overloaded campus?

6. How is productivity determined for larger units such as Colleges, Departments, or Programs, and what is the relation of such productivity measurement to determinations of order of retrenchment and liquidation of academic units?

7. To what extent does productivity, as defined, relate [to] and affect annual evaluation, promotion, and tenure?

8. What is the status of the Chairman in the bargaining unit and how is his [/her] productivity defined? (p. 38)

The questions raised by Sobel indicate that the identification of the activities that contribute to a faculty load and the determination of the weights to be assigned to each of the activities should be institutional prerogatives. According to Romney (1971),

> Institutional differences in organizational style, programs, available resources, resource allocation priorities, traditions, size, and location have a decided effect on what faculty do, how they spend their time, and what they produce. (p.2)

It is thus possible that different institutions may choose not to recognize the same activities in their differing perceptions of faculty workload.

If it were possible to develop an exhaustive list of activities that may contribute to faculty workload, it is likely that any particular institution would exercise the prerogative to recognize some, but not all, of these activities. For example, few two-year colleges recognize scholarly research as a workload component. Bolton (1965) provided a set of

guidelines for institutions to follow when considering which activities should be included. These guidelines are

1. The number of faculty available is finite;

2. There are certain tasks that the institution is required to perform. There are also finite in number, indefinite in character, variable, and subject to periodic examination;

3. There are certain tasks that the institution is expected to perform. These are defined differently by different individuals and groups and require periodic examination for purposes of clarity. These are finite in number, but more numerous than the required tasks;

4. There are certain tasks that are desirable for the institution to perform. These tend to be infinite in number, to be ill-defined, and to elicit very little critical examination;

5. Professors exist in a variety of communities (e.g., department, college, university, neighborhood, regional and state public schools, professional organizations). These various communities tend to define the required, expected, and desirable tasks differently. As a result, personal aspirations of faculty may tend to run counter to the defined tasks and expectations of the department and the institution; and

6. There are limitations that govern the quality and efficiency of work accomplished by faculty members. Time is one of these limiting factors. Unless faculty members are provided the time to accomplish those tasks that are defined as expectations and requirements of the job, evaluations on quality of performance tend to be unreliable and capricious. On the other hand, when time is provided, it can be expected that differentiations of quality and quantity of productivity will be differentially rewarded.

A compelling reason to define faculty workload in terms of activities performed exists in those institutions that have adopted budgeting systems based on functions, i.e., Planning Programming Budgeting Systems (PPBS). According to Simmons (1970),

> For budgeting purposes it would seem necessary to know how much of each of these functions [teaching, research, counseling, administration, and service to the institution] or combination of them a faculty member is expected to carry during a specified period of time. Without this knowledge it is difficult to understand how the cost of these functions is determined. (p. 33)

Halstead (1974) posited that, for budgeting purposes, the best approach to faculty workload is the full-time-equivalent faculty (FTEF) concept

> That defines the workload in terms of any combination of activities that adds up to the total work output normally expected of a faculty member employed full time. (p. 682)

He stated that the components of faculty workload are teaching; preparation for teaching; professional development; research; and service to the students, the institution, and the public. Defining faculty workload in the broad sense of FTEF, as opposed to the measure of expected teaching load, enables the institution to achieve budgeting accuracy while permitting flexibility in instructional practices.

Workload Equity

Simply stated, some faculty members expend more time and/or effort performing their professional responsibilities than others. Although it is possible to attribute a portion of the discrepancy to differences in motivation, several sources of inequity may be found in actual workload distributions. The AAUP cited six such sources. These are (a) the number of different course preparations required; (b) teaching a new course or revising an old course; (c) difficulty and scope of courses; (d) class size; (e) the amount and quality of research expected; and (f) other duties,

specifically the extent of involvement in such activities as student counseling, committee work, professional societies, and administration (Megaw, 1968).

The difficulty of attaining equity in faculty workload has been a concern for several years. In 1929, Reeves and Russell posited that

> The evaluation of faculty load is an extremely difficult problem. Teaching duties and other professional duties vary tremendously from institution to institution and from individual to individual within a given institution. In fact, the factors involved in determining total faculty load are so numerous and so varied as almost to preclude precise determination by any mechanical method. No thoroughly scientific method of measuring faculty load is now available. Existing measures are unsatisfactory and incomplete. The answers are not yet in. Yet, as a practical necessity, some method of measuring and adjusting faculty load even though only approximate must be employed. (Reeves & Russell, 1929, p.165)

According to Swofford (1978), the most common means of measuring faculty workload today are student credit units (the sum of the student credit hours of each course or section that a faculty member teachers), weekly student contact hours (WSCH, the product of the number of students and the number of hours a faculty member meets the students each week), and variations or combinations of these measures. Swofford believed that "each system is too restrictive because it measures only one thing, and each has built-in discriminations against some of the faculty" (p. 52). Nevertheless

> The concept of an equitable load has a validity in establishing certain boundaries and, most importantly, in helping to prevent the creation and perpetuation of gross inequities that could severely affect the morale of a faculty. (Swofford, 1978, pp. 52-53)

Efforts to provide workload equity have resulted in the establishment of various "point systems" at many institutions. One such point system was designed by Howell (1962). His approach was to assign points to each of the activities that are recognized by the institution as part of a faculty member's responsibilities but that are not necessarily specific components of the contractual relationship (see Table 2).

Table 2
Howell's Point System For Faculty Workload

Code	Points	Type of Assignment
A	10	Each hour of undergraduate work other than independent study
B	15	Each hour of graduate work other than independent study
C	5	Each hour of laboratory instruction (direct)
D	1	Each hour of laboratory instruction (supervision only)
E	½	Each student above 25 in class
F	-½	Each student less than 25 in class
G	3	Each hour of independent study instruction (Music - 5 points)
H	10	Each hour released time for whatever purpose
I	10	Each additional preparation beyond three
J	5	Serving on standing committee
K	10	Serving as chairman of standing committee

Source: Howell (1962).

Adams (1976) confirmed that Howell's point system takes into account all facets of a faculty member's job and can be used to provide workload comparisons among different faculty members. He found two weaknesses.

> [Howell's point system] fails to take into account the fact that a course in one department may be a heavier load than a course in another department (e.g., a three-hour course in Freshman English, where the instructor grades all papers, is no doubt heavier than a three-hour course in a department where there is little paper work), and it does not presume to state what the [full] load (total points) should be. (Adams, 1976, p.2)

Through the years, there have been several studies conducted to determine the amount of time, on the average, that a faculty member spends per week in job-related activities. Fifty such studies, the first of which was conducted in 1924, were analyzed by Romney (1971). Many of these studies resulted in the development of time-spent formulas in which the number of weekly hours spent by a faculty member in his/her duties is expressed as a function of one or more variables. On such time-spent formula, derived by Sexon in 1962, was presented and analyzed by Adams (1976). Sexon's formula only considered time spent for classroom functions (hours in the classroom or laboratory, lesson preparation time, and time spent in evaluating student work). Sexon's formula is

$$T = x + .7x + .08y,$$

where

T = weekly hours for classroom function,

x = weekly hours in the classroom or laboratory, and

y = number of students taught.

The term $.7x$ represents preparation time and $.08y$ represents the time spent evaluating students. For example, a faculty member teaching 15 hours per week with a student load of 150 will, according to Sexon, spend

15 + .7(15) + .08(150) = 37.5 weekly hours for classroom functions alone. More specifically, .7(15) = 10.5 hours will be spent on lesson preparation and .08(150) = 12 hours will be spent on evaluation of student work. Sexon developed his formula from time charts kept by teachers, interviews, and other measures (Adams, 1976). Weaknesses in Sexon's approach are (a) the formula describes an average and fails to recognize differences in preparation time or evaluation time required by different courses and (b) the formula does not consider time consuming duties other than teaching.

Sexon's formula adds substance to the position of the AAUP that class size is a source of workload inequity. Lombardi (1974) posited that, although class size is an important consideration in analyzing faculty workload, it is not as significant as contact hours because "they are fixed demands over which [the faculty member] has little control. Within limits, the size of the class causes little concern since the time demands do not vary directly to the number of students" (p.3). Concerning the relationship of class size to student achievement, research has not been able to show that class size is significant (Lombardi, 1974; Nickens, Zucker, & Garner, 1974).

Workload and Collective Bargaining

In their analysis of over 300 collective bargaining agreements, Douglas et al. (1980) found that over 80 percent of them addressed the issue of faculty workload. The majority of two-year college agreements provided for a yearly workload of 30 credits per faculty member whereas the norm in four-year colleges was 24 credits per faculty member per year. Assuming a two-semester or three-quarter academic year and assuming one weekly contact hour per credit, these data specify a 15 contact-hour week for two-year college faculty and a 12 contact-hour week for four-year college faculty.

According to Goeres (1978), collective bargaining agreements generally address the issue of faculty workload in terms of minimums and maximums.

> Workload minimums are defined primarily for the benefit of the employer to ensure that faculty are performing duties at no less than a defined minimum level. Workload maximums (or limits), on the other hand, are defined primarily for the benefit of the employee, to ensure that he or she is not overworked; that is, not treated capriciously or unfairly in terms of workload. (p.2)

Goeres' study of collective bargaining agreements uncovered various activities that generally allow for a reduction in the basic teaching load. Included in these activities are (a) holding the position of department chairperson, (b) preparation and/or administration of a grant or other outside funded project, (c) development of new courses or programs, (d) administrative activities or services, (e) developmental activities, (f) special assignments, (g) service as chairperson of standing committees, (h) service as secretary of the faculty senate (i) service as president of the teacher's association, and (j) service as the chief union negotiator. Collective bargaining agreements provide evidence that faculty workload is not limited to specific teaching assignments and that institutions recognize this concept by including a variety of activities in workload definitions. Such recognition is fundamental to the issue of workload equity.

Workload in the Community College

The "publish or perish" norm that is reportedly so prevalent among university faculty does not exist at the community college level. The absence of a research requirement provides more time for community college faculty to concentrate on teaching. Therefore, as a general rule, the teaching load is heavier in the community college than in the university. According to Medsker and Tillery (1971),

> Teachers in the [community/] junior colleges carry heavier class loads than do those in four-year institutions and are thus subject to a comparatively unfavorable faculty-student ratio. This has

> generally been rationalized on the basis that faculty in the [community/] junior college are not expected to engage in research, nor do they deal with upper-division and graduate students whose needs are presumed to be more exacting than those of lower-division students. (p. 92)

In a study of policies in nine Florida community colleges, Nickens, Zucker, and Garner (1974) found two that actively discouraged their faculty from engaging in research by stating that such activities were not required. The remaining colleges had no written policies that mentioned faculty research.

Current practices

Teaching load can be measured either by credit hours or by contact hours. These measures are not necessarily equivalent. According to Lombardi (1974),

> A credit hour in a subject that requires outside preparation for the instructor or the student is equal to one contact hour. A credit hour in a laboratory, shop, or performance class that requires no outside preparation is equal to one-half to three-fourths of a contact hour [i.e., two hours per week in class for one credit to four hours per week in class for three credits]. In a few subjects, particularly English composition or writing classes, a credit hour is worth approximately one and one-third contact hours. This difference between credit and contact hours has led to faculty insistence that . . . [teaching loads] be defined in terms of contact hours rather than credit hours. (p.2)

The standard teaching load in community colleges today, with few exceptions, seems to be 15 hours per week with a slightly higher requirement for laboratory, shop, physical education, and other nonlecture class meetings (Monroe, 1972). According to Medsker and Tillery (1971),

> The number of teaching hours per week . . . [tends] to be in the 15 to 18 hour range--with some allowance on the lower side for "lecture" courses and a slightly higher load when much of the work is in a laboratory situation. (p. 92)

The Los Angeles City Community Colleges have developed a teaching load formula in which the weekly contact hour load varies from 15 for a program of lecture classes to 20 for laboratory classes. The formula also stipulates a minimum of 450 WSCH. Instructors carrying 15-hour loads who

fail to meet the 450 WSCH standard may be assigned an extra class or be required to perform an additional duty. Modifications to the formula have reduced the contact hour requirement for English composition instructors to 12 and have eliminated the differential between lecture and laboratory classes in some departments (Lombardi, 1974).

In a survey of 767 community colleges conducted by Rosomer, Randolph, and Jonas (1981), it was found that the practice of equating workload assignments to "lecture hour equivalents" is widespread. Each hour in the laboratory, for example, can be expressed as a fractional multiple of a lecture hour. The lecture hour is a widely used reference point for quantifying full-time faculty workload. Over 90 percent (702 out of 767) of the community colleges defined a full workload to be the equivalent of 15 weekly lecture hours.

Whether or not credit hours and/or contact hours accurately measure the amount of "work" faculty members perform is an issue. Each is easily quantified but neither necessarily reflects the number of hours that faculty spend in performing assigned duties. In a time-analysis study conducted at Manatee Junior College in Bradenton, Florida, Stivers (1961) reported that faculty members spend from 38 to 62 hours per week on instructional tasks. The wide range existed among the faculty members despite the fact that their teaching loads were equitable in terms of lecture hour equivalents.

Workload trends and recommendations

During the 1950s and early 1960s, community college faculty were able to persuade administrators and state agencies to reduce workload requirements. More recently, real-dollar budget cuts have forced administrators to look for ways to improve institutional cost-effectiveness. According to Lombardi (1974),

> The focus has been on the more effective use of faculty ranging from minor changes in workload to drastic reform of the teaching-learning process. Faculty workloads have been singled out in the economy proposals because education is a labor-intensive enterprise in which labor costs comprise 70 to 80 percent of the budget and faculty salary and other faculty expenditures account for 50 percent of total costs of instruction. Economies in other areas are helpful but they do not produce the high returns possible in faculty workload increases. (p. 10)

Economy measures through increased workloads can be achieved either by increasing the number of weekly lecture hours per faculty member or by increasing the average class size. According to Lombardi (1974), faculty are more likely to accept the latter. Mayhew (1979) recommended that class size and student-faculty ratios be increased because there are no data that demonstrate the existence of a relationship between class size and student achievement. In a study of faculty load conducted in 1968 for the San Jose (California) City College by the Field Service Center at the University of California at Berkeley, it was recommended that the college work toward a 500 weekly student contact hour load per FTEF, allowing for legitimate variations among programs and faculty (Medsker & Tillery, 1971).

In effect, adjusting faculty workload by raising average class size increases faculty productivity. Average class size reflects the number of student contact hours or student credit hours per FTEF. In states that fund colleges on the basis of student contact hours or student credit hours, increasing class size provides more funding per full-time faculty position and enables the colleges to improve their financial situations.

The M-DCC Point System

At Miami-Dade Community College (M-DCC) in Miami, Florida, faculty workload for the entire spectrum of instructional arrangements is determined on the basis of a point system. The objectives of the point system are

> To provide equity in staff loads, to allow for flexibility in utilization of staff, to provide a means for planning various

> instructional arrangements, and to provide a basis for the development of a cost-effectiveness analysis system for instruction. (Board of Trustees, Miami-Dade Community College, 1982, Procedure #2150, p. 1)

Various categories of faculty activity, each of which is awarded a certain number of points, may contribute to a faculty member's workload. A full workload is defined to be the accumulation of a specified number of points.

The M-DCC point system awards points in five categories of faculty activity. These are

1. Presentation. This is the equivalent of lecture/discussion and assumes a normal requirement of outside preparation. Class size is not a factor in the assignment of points.

2. Supervision. This is the time spent in interchange with students and supervision of learning activities in sessions that do not carry the burden of as much outside preparation which is normally associated with a presentation session. The best example of supervision is a typical science laboratory.

3. Administration. This is the category used in case the nature of the instructional arrangement generates an unusual amount of paperwork, grading, or other administrative activity. For example, administration points may be awarded to teachers of very large sections (60 or more) if it can be demonstrated that the size of the class adds a significant burden.

4. Planning and Development. This is the time set aside to plan and develop educational programs or materials as needed for effective delivery. When associated with current presentation, it is recognized only when there is a demonstrated need for time beyond the normal expectation. Planning and development points may also be assigned for accomplishing curriculum projects.

5. Management. This category is used for the direction of activities of a group of faculty members or professional staff. The most common example is a department chairperson (Board of Trustees, Miami-Dade community College, 1982).

The reference unit of measure used to determine the point value for activities in the various categories is the contact hour of presentation. A contact hour is defined to be 50 minutes. During a 16-week semester, one presentation contact hour per week is assigned a value of four points. A faculty member whose workweek consists of 15 contact hours of presentation achieves a workload of 4 x 15 = 60 points. Therefore, during a 16-week semester, a full faculty workload is defined to be 60 points, with a tolerance of plus or minus two points. The 60-point load may be achieved via any combination of the recognized categories of faculty activity.

One supervision contact hour per week during a 16-week semester is assigned a value of three points. A faculty member whose teaching assignment is exclusively in a laboratory setting, and hence who earns only supervision points, is required to contribute 20 hours per week in order to achieve a full load of 60 points. If the faculty member's assignment is a mixture of presentation and supervision, then the full 60-point load is achieved through fewer than 20, but more than 15, contact hours.

Decisions for point assignments in the other categories (administration, planning and development, and management) are made by department chairpersons in conjunction with higher-level administrators or are dependent on college guidelines and formulas. For example, the number of management points awarded to a department chairperson is dependent on the number of full-time faculty members that he/she supervises.

In addition to two 16-week semesters, M-DCC has two six-week summer terms. A full faculty load during the combined summer terms is defined to be 48 points, with a tolerance of plus or minus two points. The 48-point load is usually achieved by carrying 24-point loads during each term, but other combinations are possible.

M-DCC provides two types of contracts to full-time teaching faculty. The "College Year Contract" applies to those faculty members who have teaching responsibilities during both 16-week semesters and both six-week terms. The annual expectation for faculty members on College Year Contracts is 60 + 60 + 48 = 168 points. The "Basic College Year Contract" applies to those faculty members who have teaching responsibilities during both 16-week semesters and only one six-week term. The annual expectation for faculty members on Basic College Year Contracts is 60 + 60 + 24 = 144 points (Board of Trustees, Miami-Dade Community College, 1982).

The M-DCC point system contains provisions for work overloads and underloads. A workload that exceeds the required load by more than two points in any given term is considered to be an overload. Faculty members may be paid at a specified rate for the surplus points, or the points may be transferred to a subsequent term in order to offset an underload. The transfer of points among terms may only be accomplished within a single academic year (Board of Trustees, Miami-Dade Community College, 1982).

The workload for part-time instructional personnel is covered by the M-DCC point system. Such individuals are employed by departments on the basis of need and there is no workload expectation applied to them as there is to full-time personnel. Part-time personnel are paid on the basis of a dollar per point rate which may vary among individuals, due to length of service or other factors, but which must be within a specified range.

Part-time assignments in categories other than presentation and supervision, although rare, are possible (Board of Trustees, Miami-Dade Community College, 1982).

The M-DCC point system has a provision to monitor the workload of instructional support paraprofessionals. Under the supervision of a professional staff member, a paraprofessional's load may be allocated for such instructional activities as classroom supervision, lab supervision, or program advisement. A full-time paraprofessional load is based upon a workweek of 37.5 hours which is equated to 40 points during each 16-week term and to 30 points for the combined six-week terms. The annual expectation for a full-time (37.5 hours per week for 44 weeks) paraprofessional is 40 + 40 + 30 = 110 points. Part-time paraprofessionals are awarded appropriate fractional multiples of this expectation and are compensated on that basis (Board of Trustees, Miami-Dade Community College, 1982).

Summary

The M-DCC point system is a feedforward control system that sets a standard for faculty workload. When deviations, i.e., workload inequities, occur, the system provides adjustments in the form of compensation or transfer of points. The system can be modified by deleting or adding recognized categories of activity. Other postsecondary institutions can adapt the system to fit their specific needs. The system recognizes aspects of faculty activity in addition to teaching, a feature that is of significant concern to scholars in the field and is addressed in most collective bargaining agreements. In states where community colleges receive funds on the basis of enrollment-driven formulas, the M-DCC point system can be incorporated into a productivity model that can be used to measure the cost-effectiveness of instructional programs.

CHAPTER III

MODEL DEVELOPMENT

The data presented in this chapter were collected from officials or staff members of the state agencies responsible for community college affairs in 42 of the contiguous 48 states. The six states omitted from the study do not have extensive community college systems. These states are Idaho, Indiana, Maine, Rhode Island, South Dakota, and Vermont. The 42 states surveyed account for 98.7 percent of the national enrollment in public two-year colleges (American Association of Community and Junior Colleges, 1983).

Subsequent to the collection and analysis of the data, faculty workload and productivity models are derived. The productivity model is written as an equation of the form

$$P = \frac{FU}{FTEF} \quad ;$$

where (a) P is productivity, (b) FU is an enrollment-based funding unit from which community colleges generate state income, and (c) FTEF represents the number of workload units generated by the faculty, i.e., the number of full-time equivalent faculty units.

The Findings

The data were collected by means of telephone interviews conducted in June, 1983. The purpose of each interview was to identify the elements of the productivity model. Specifically, each individual interviewed was asked to provide answers to the following questions:

1. Is enrollment a factor in determining the distribution of state funds to community colleges?

2. How is enrollment measured?

3. If various enrollment measures are calculated for different programs, which measure is predominant?

4. How significant are state funds in the total financial support of community colleges?

5. Are there any state-level provisions that define a standard workload for community college faculty members?

A state-by-state summary, including some peripheral data, follows. The names of the officials or staff members interviewed are listed in Appendix A.

Alabama. Enrollment is a factor in the distribution of state funds. The state support is measured in terms of $/full-time equivalent student (FTE). In the junior colleges, one annualized FTE is 60 quarter hours of credit. In the technical colleges, one annualized FTE is 1,296 student contact hours (SCH), based on attendance of six hours per day over the 216-day academic year. Excluding student tuition and fees, the community colleges are 100 percent state supported. There are no state-level workload provisions but, as determined by local presidents, junior college faculty members are expected to teach between 15 and 21 credits per term and maintain a duty schedule of 35 hours per week, including teaching, advising, and other appropriate duties. Technical college faculty members are expected to spend 30 hours per week in the classroom or shop and maintain a duty schedule of 40 hours per week. The technical college faculty duty schedule is five hours per week longer than that of the junior college faculty because they are expected to have lunch on campus.

Arizona. Enrollment is a factor in the distribution of state funds. Enrollment is measured in terms of FTE, where one annualized FTE is 30

semester credits. Each institution receives a fixed $/FTE for the first 1,000 FTE and a smaller amount per FTE in excess of 1,000. Student credits are the only units aggregated to FTE. There is a local contribution to support community colleges. Systemwide, the state provides 23.4 percent of the support and the districts provide 45.2 percent. The remaining support is derived from tuition, fees, and other sources. Faculty workload is a local prerogative.

Arkansas. Enrollment is a factor in the distribution of state funds. Enrollment is measured in terms of FTE, where one annualized FTE is 30 semester credits. In 1975, several vocational schools, whose state support was derived from a SCH-based formula, were incorporated into the community college system. They were required to abandon the use of SCH and convert to student credits. A small amount of local support is provided by the counties. Local funds account for 1 percent of the total support whereas the state's share is 61 percent. Faculty workload is a local prerogative.

California. Enrollment is a factor in the distribution of state funds. Enrollment is measured in terms of the number of students in average daily attendance (ADA), where one ADA is 525 SCH. All credit programs are funded at the same rate, but non-credit programs receive state funds at a different rate. The local districts provide 26.6 percent of the total support whereas the state provides approximately 65 percent. Students are not required to pay tuition. The state has imposed growth limitations on each district and the excess ADA are not funded. During the 1982-83 academic year, 1.5 percent of the credit ADA and 3.8 percent of the non-credit ADA in the system were unfunded. Faculty workload is a local prerogative and is generally an issue for collective bargaining.

Colorado. Colorado contains nine community colleges in its state system. In addition, there are four community colleges that are independently controlled by local districts. The state provides full support to the state colleges and partial support to the local colleges. The aid to the local colleges provided by the state ranges from 23 to 50 percent of total support. Local support ranges from 27 to 60 percent. In both systems, state support is FTE-dependent. One annualized FTE is either 30 semester credits or 45 quarter credits. The state colleges receive state funds on the basis of a "block funding system" which provides a specified amount per Colorado resident FTE. The state subsidy to local colleges is based on the number of Colorado resident FTE enrolled plus a supplement for vocational students. In addition to an enrollment factor, state funding is program-based. Twenty-five disciplines, all of which are included among those in the Higher Education General Information Survey (HEGIS), are funded at different rates. At the present time, there are no state-level provisions for workload, but the issue is under study.

Connecticut. Enrollment has not been a factor in the distribution of state funds since 1975. The state applies an "historical budget" process that utilizes inflation data to allow community colleges to continue at the same level from year to year. Enrollment, in fact, has remained relatively constant during this period. An enrollment-driven formula is being developed, with expected application by 1987. Nonetheless, the community colleges are currently required to report enrollment data. Required are full- and part-time headcount figures and total FTE, where one annualized FTE is 30 semester credits. There is no local contribution and the tuition collected by the colleges is returned to the state treasury. Faculty

workload requirements are included in a single systemwide collective bargaining contract.

Delaware. Enrollment is a small factor in the distribution of state funds to the four campuses of Delaware's one community college. The budget requested is deliberated by the legislature and the governor. Enrollment data are reported as FTE, where one FTE is 12 semester credits per term. There is no local contribution. Tuition, except that collected from students in continuing education programs, is returned to the state treasury. Continuing education is fully supported by tuition and receives no state support. There are no state-level provisions for workload.

Florida. Florida has abandoned its enrollment-driven, program-based funding formula and has adopted a categorical, negotiated system. Each community college receives incremental increases from year to year. The new funding process gives the legislature strong program control. Enrollment data are reported but are used only for comparisons with those reported by the universities and the public schools. These data are reported in terms of FTE. In the community college system, one FTE is 40 semester credits in the credit programs and 900 SCH in the non-credit developmental and vocational programs. These compare to the university FTE (40 semester credits) and the public school FTE (900 SCH), respectively. The problem inherent with this procedure is that the two types of FTE are, in fact, not compatible within the community college system itself: an FTE of 40 semester credits is based on an 11-month university academic year whereas an FTE of 900 SCH is based on a nine-month public school academic year. There is no local support of community colleges, so, excluding tuition and fees, the system is fully state supported. Faculty workload is a local prerogative

subject to minimum requirements specified by state retirement laws. The state-mandated mimimum is 15 hours per week.

Georgia. Enrollment is a factor in the distribution of state funds. Enrollment is measured in terms of FTE, where one FTE is 15 quarter credits per term. One college (DeKalb) is locally governed and receives part of its support from the state and part from local property taxes. The remaining colleges have no local contribution. The State Board of Regents is the governing board for all the junior colleges in the state system. A Board of Regents policy specifies the workload requirement to be 15 hours per week, with more contact hours for faculty members engaged in laboratory supervision.

Illinois. Enrollment is a factor in the distribution of state funds. In addition, the state applies a "unit-cost system" that provides different funding rates in seven program categories. Enrollment is measured in terms of FTE, where one annualized FTE is either 30 semester credits or 45 quarter credits. In those programs that do not generate credits, a conversion formula is applied. Specifically, 45 SCH are equated to one semester credit and 30 SCH are equated to one quarter credit. Local support is derived from property and corporate taxes. Systemwide, the state provides 46 percent of the total support and local districts provide 42 percent. Faculty workload is a local prerogative.

Iowa. At the present time, enrollment is not a significant factor in the distribution of state funds. There is currently under consideration a proposal to apply a formula that distributes funds on the basis of cost/SCH in four cost centers: (a) Arts and Science, (b) Vocational/Technical, (c) Adult Education, and (d) High School Joint Effort Programs. The formula exists, but has not yet become the basis for allocation. One small step

toward implementation was recently accomplished--the legislature approved $400,000 to be distributed by the formula for fiscal year 1984. Enrollment data are reported in terms of FTE in credit programs. Non-credit programs receive no reimbursement from the state. In the credit programs, one FTE is 540 SCH, where one SCH is counted for each student lecture hour and for every two student laboratory hours. There is a local contribution that, systemwide, accounts for between 10 and 11 percent of the total support. State funds provide 50 percent of the support. There are state-level workload standards, and these standards are given in terms of maximums. In Arts and Science, the maximum workload is 16 credits per semester with a reduced load for first-year instructors. In Career Education, the maximum load is 30 hours per week.

Kansas. Enrollment is a factor in the distribution of state funds. Enrollment is measured in terms of FTE, where one FTE equals 15 semester credits per term. Vocational FTE generate a 50 percent supplement. No SCH units are used for funding purposes. However, there do exist some contracts with area vocational schools through which community colleges award credit. In these cases, 900 minutes of attendance is equated to one semester credit. Local contributions include property taxes and out-of-district tuition paid by counties that do not sponsor community colleges but have residents who attend community colleges in other counties. The state's share of total support is 30 percent. Faculty workload is a local prerogative.

Kentucky. Enrollment is not currently a factor in the distribution of state funds. All community colleges are part of the University of Kentucky system, and their budget requests are reviewed by the chancellor. An enrollment-driven funding formula has been developed and approved by the state's Council of Higher Education, but it has not yet been implemented.

Enrollment data are reported and one annualized FTE is defined to be 32 semester credits. Only two of the state's 13 community colleges receive local support. There are no state-level provisions for faculty workload. Workload standards are set by the chancellor. Local boards exist only in an advisory capacity--the governing board for community colleges is the University of Kentucky Board of Trustees.

Louisiana. There is one state supported community college in Louisiana. The college utilizes enrollment data in its request for state funds. Enrollment data are reported as student credits distributed among the HEGIS disciplines, and the concept of FTE is not defined. There is no local contribution. The state strives to achieve a 75 percent support level with the remaining funds to be generated from student tuition and fees. Workload standards are set by the local governing board.

Maryland. Enrollment is a factor in the distribution of state funds. Enrollment is measured in terms of FTE, where one annualized FTE is 30 semester credits. Of the 17 community colleges in the system, 13 are classified as large. The four small colleges are called regional colleges. The basic state subsidy per FTE to the regional colleges is 1.84 times higher than that to the large colleges. But each large college receives an additional flat grant of $200,000 and a part-time student supplement of $10 per unduplicated headcount. This supplement applies only to part-time students enrolled in credit programs. Non-credit programs are funded separately by equating 15 SCH to one semester credit. Each district provides local support. Systemwide, the state provides 35 percent of the total support, but the level of state support varies from county to county. Richer counties receive the same state subsidy per FTE as the poorer counties but can generate more local funding. No attempt is made by the

state to equalize overall support. Workload is a local prerogative and an issue for collective bargaining at two colleges.

Massachusetts. Enrollment is a factor in the distribution of state funds. Enrollment is measured in terms of FTE, where one FTE is 15 semester credits per term. The funding formula utilizes enrollment data from the Fall term only. The state is working toward a formula that is FTE- and discipline-based. There is no local support for community colleges. Faculty workload standards are specified in a single systemwide collective bargaining contract.

Michigan. Enrollment is a factor in the distribution of state funds, but a less significant factor recently for two reasons. First, some community colleges have experienced decreases in enrollment. Second, the state's fiscal crisis has resulted in across-the-board reductions in all state supported entities. With the recent improvement in the economy, increases have also been across the board. Enrollment data are reported in terms of "Fiscal Year Equated Students" (FYES), where one FYES is 31 semester credits for a 12-month period. The funding formula, which has not been utilized for the past few years, specifies four funding categories: General Liberal Arts, Health, Occupational, and Business. Local contributions are derived from property taxes. The state provides 50 percent of the total support. The state statute that specified faculty workload requirements was struck down by the courts. Workload remains a local prerogative. Collective bargaining exists in nearly all of Michigan's community colleges.

Minnesota. Enrollment is a factor in the distribution of state funds. Under a process called "Average Cost Funding," enrollment data from a given year are used to determine the funding level two years later. Enrollment is measured in terms of FTE, where one annualized FTE is 45 quarter credits.

The Average Cost Funding process specifies three cost categories: High Cost, Medium Cost, and Low Cost. Various disciplines are placed in these categories on the basis of previous cost studies. There is no local contribution to support community colleges. Faculty workload is an issue that is negotiated at the state level. The current maximum workload is 16 credits per quarter and 45 credits per year or 20 contact hours per quarter and 60 contact hours per year.

Mississippi. Enrollment is a factor in the distribution of state funds. The funding specifies four funding categories:

1. Full-time (12 or more semester credits per term), daytime, Mississippi resident students in academic programs;

2. Full-time, daytime, Mississippi resident students in vocational programs;

3. Part-time, evening, Mississippi resident students; and

4. Full-time, Mississippi resident Associate Degree Nursing students.

Part-time, evening enrollment (category 3) is measured in terms of FTE, where one annualized FTE is 30 semester credits. Community colleges receive a supplement for each (full-time) Associate Degree Nursing student. A full-time vocational student (category 2) is one who, on the average, is in attendance for 25 hours per week, although this definition varies from program to program. Local property taxes contribute to community college support. Direct state aid accounts for 41 percent of total support. An additional 15 percent in supplemental aid is contributed by the state agency that supports vocational education in the public schools. The Standards of the Junior College Commission recommends that the maximum faculty workload be 450 SCH per week and 16 credits per semester. The Commission equates

two WSCH of laboratory and three WSCH of shop to one semester credit. The recommended duty schedule for all faculty is 35 hours per week.

Missouri. Enrollment is a factor in the distribution of state funds. Funds are generated on a $ per credit basis, with no aggregation of credits equated to one FTE. The funding formula specifies one general category and two vocational categories. There is a local contribution and, by law, the state's level of support cannot exceed 50 percent. The current level of state support is 40 percent. Faculty workload is a local prerogative.

Montana. Projected enrollment, anticipated cost per student, and a legislatively-set percentage of state support are the factors that determine the distribution of state funds. Prior to a legislative session, each community college utilizes enrollment projections and anticipated cost per student to determine its budgetary needs. Legislative and executive department analysts provide assistance in this endeavor. The analysts and college officials arrive at the final approved budget. The legislature then sets a specific percentage of state support to determine the state's appropriation. Each college is required to provide the difference between projected need and state support through tuition, fees, and local levies. The current level of state support is 53 percent. Enrollment is calculated in terms of FTE, where one FTE is 12 semester credits per term. Faculty workload standards are set by the local Boards of Trustees.

Nebraska. Enrollment is not a factor in the distribution of state funds. Yearly budgets are negotiated and allocations are based on budgets of the previous year. State officials plan to study the feasibility of funding on the basis of enrollment and/or programs. Enrollment data are reported in terms of headcount within the various HEGIS disciplines. Local property taxes help support the community colleges. The state is currently

providing 38 percent of the total support, and the local share is also 38 percent. Workload is a local prerogative.

Nevada. Enrollment is a factor in the distribution of state funds. The funding formula is FTE-driven, where one annualized FTE is 30 semester credits. There is some differentiation of funding per FTE based on program student/faculty ratios. Moreover, there is a rural factor applied for colleges in low population areas. There is no local support of community colleges. In 1981 the legislature imposed a workload requirement as a condition for faculty pay raises. The requirement specified that the combined university and community college faculty workload must achieve an average of 12 contact hours per week. This was a one-time restriction and an attempt to increase workload. The 12-hour standard was achieved through a 15-hour week from community college faculty and a nine-hour week from university faculty. The 1983 legislature imposed no such requirement--the state's financial condition resulted in no faculty pay raises.

New Hampshire. There are no community colleges in New Hampshire, although some universities offer two-year programs. One technical institute and six vocational/technical colleges receive state aid, but enrollment is not a factor in the distribution of state funds. All budgets are negotiated. There is no local contribution. Faculty workload is a local prerogative, but the issue is under study at the state level.

New Jersey. Enrollment is a factor in the distribution of state funds. Enrollment is measured in terms of FTE, where one annualized FTE is 30 semester credits. In addition, the funding formula provides different funding rates among six program categories. Effective 1984, SCH will not be aggregated into FTE in any program. Local contributions are derived from county property taxes. Financial support is approximately evenly split

among state sources, local sources, and student tuition. Faculty workload is a local prerogative.

New Mexico. Enrollment is a factor in the distribution of state funds. The funding formula is FTE-driven, where one annualized FTE is 30 semester credits. The formula also specifies nine separate program categories called "funding clusters." In the vocational cluster, 900 SCH are equated to one annualized FTE. New Mexico has two types of community colleges, each with a different local effort requirement. The locally-controlled colleges have a two to five mill required levy and the branch campuses carry a two mill requirement. Systemwide, the state provides 80 percent of the total support. Local contributions account for 10 percent. Faculty workload is a local prerogative.

New York. Enrollment is a factor in the distribution of state funds. Enrollment is measured in terms of FTE, where one annualized FTE is 30 semester credits. State funds are allocated on the basis of a specified amount per FTE but the allocation to any community college cannot exceed 40 percent of its net operating cost. Colleges receive an additional supplement for every FTE enrolled in business or technical programs. Local support, including sponsor chargebacks, accounts for 39 percent. Faculty workload is a local prerogative and is generally an issue for collective bargaining. A typical faculty workload is 15 hours per week. There is a higher requirement for laboratories and a lower requirement for classes with large enrollments and/or an unusual amount of paperwork, such as English composition.

North Carolina. Enrollment is a factor in the distribution of state funds. Enrollment is measured in terms of FTE, where one FTE is 704 hours of class membership hours over four quarters. A formula to differentiate

funding on the basis of programs is under study. Local contributions, derived from county property taxes, are used for plant operation and maintenance. The state provides 77.8 percent of the total support. The state-level faculty workload provision specifies a range of 12 to 15 hours per week.

North Dakota. Enrollment is not a factor in the distribution of state funds. The state's three community colleges are all part of local school districts. Budget requests, however, are somewhat enrollment-driven. Enrollment data are expressed in terms of FTE, where one FTE is 16 credits per semester. The state provides each college the difference between total need and what can be raised locally. A local levy of eight mills is a prerequisite for state aid. The state's share of the total support is slightly more than 50 percent. Subject to voter approval in the Fall 1984 general election, the community colleges will be removed from the jurisdiction of the local school boards and be governed by the State Board for Higher Education. Local support will vanish and the system will be fully state supported. Faculty workload standards are currently set by the local boards.

Ohio. Enrollment is a factor in the distribution of state funds. Enrollment is measured in terms of FTE, where one annualized FTE is either 30 semester credits or 45 quarter credits. FTE-based formulas exist for seven separate programs, or "expenditure levels": three general studies programs, three technical programs, and one program called Baccalaureate I. Additional funds are provided for libraries and plant operations. These funds are not enrollment-dependent. Some, but not all, of the community colleges receive local support. Faculty workload is a local prerogative.

Oklahoma. Enrollment is a factor in the distribution of state funds. Enrollment is measured in terms of FTE, where one annualized FTE is 30 semester credits. In addition, the state provides differential funding in 62 of the HEGIS disciplines. Four of the 14 community colleges receive local support. Local income is not deducted from the state allocation. The remaining 10 colleges are fully state supported. Workload standards are set by the local governing boards.

Oregon. Enrollment is a factor in the distribution of state funds. Enrollment is measured in terms of FTE. In college transfer programs, one annualized FTE is 45 quarter credits. In vocational and non-credit programs, one annualized FTE is 680 SCH, based on 20 SCH per week for three quarters. Community colleges receive a specified amount per FTE for the first 1,100 FTE and a lower amount per FTE in excess of 1,100. Local support is derived through property taxes. The state's share of the total support is now 32 percent. Local contributions account for 46 percent. In 1979, state and local shares were 46 and 30 percent, respectively. The state's fiscal crisis has necessitated the reversal of state and local burdens. Faculty workload is a local concern and is generally a collective bargaining issue.

Pennsylvania. Enrollment is a factor in the distribution of state funds. Enrollment is measured in terms of FTE, where one FTE is either 12 part-time credits or one full-time student. A full-time student is one who registers for 12 or more credits in a semester. In non-credit courses, 15 class hours and 30 laboratory hours are each equated to one credit. Vocational programs receive an additional supplement of $150 per FTE. Total support is evenly divided among state sources, local sources, and student fees. Workload is a local prerogative.

South Carolina. Enrollment is a factor in the distribution of state funds. An enrollment-driven formula is applied to initial budget requests, and that formula is used to distribute funds from the state appropriation to the colleges in the system. Enrollment is measured in terms of FTE, where one annualized FTE is 45 quarter credits. The funding formula, however, is applied to Fall quarter enrollment data. In addition, the formula provides for differential funding rates over 25 disciplines within the HEGIS taxonomy. In non-credit, continuing education courses, enrollment is measured by SCH. On the average, 1.42 SCH per week per quarter are equated to one quarter credit. Local contributions are derived from county property taxes. These are targeted for plant maintenance and operation costs. Excess local contributions, if any, can be used for program enhancement. If local contributions do not totally support maintenance and operation needs, students are assessed a plant fee. The state and local shares of the total support are 70 and 9 percent, respectively. A state board policy sets a faculty workload range of 15 to 22 hours per week. Within this range, local boards are free to set their own requirements. There is no collective bargaining.

Tennessee. Enrollment is a factor in the distribution of state funds. Enrollment is measured in terms of FTE, where one FTE is 15 quarter credits per term. Fall enrollment data are used in the funding process. The state provides differential funding on the basis of a Fall term cost study of disciplines in a prescribed program taxonomy. Continuing education is required to be self-supporting, but the state provides a fixed administrative subsidy for these programs that is not enrollment-dependent. No support is derived from local sources. The state mandates a 15-hour per week faculty workload.

Texas. Enrollment is a factor in the distribution of state funds. Enrollment is measured in terms of SCH with no attempt to aggregate them to an FTE. The state provides differential funding rates among 19 disciplines. Local contributions are derived from property taxes and the state provides 65 percent of the support systemwide. Faculty workload is a local prerogative.

Utah. Enrollment is a factor in the distribution of state funds, but there is no enrollment-driven formula. Instead, funding is programmatic and incremental with enrollment a consideration. Enrollment is measured in terms of FTE, where one FTE is 10 credits per quarter, annualized to 30. A procedure to provide differential funding among various programs is currently being studied. SCH are counted and equated to FTE in some vocational programs. Community colleges are under the same governing board as the universities. There are no local contributions. Workload is a local prerogative, but the state Board of Regents occasionally conducts workload studies.

Virginia. Once funding guidelines are set by the legislature, enrollment is a factor in the distribution of state funds. Enrollment is measured in terms of FTE, where one annualized FTE is 45 quarter credits. In addition, differential funding rates are applied among the appropriate HEGIS disciplines. There is no local support. Workload guidelines are set by the state board. The current standard is 12 to 15 credit hours per term.

Washington. Enrollment is a factor in the distribution of state funds. Enrollment is measured in terms of FTE, where one annualized FTE is 45 quarter credits. Differential funding rates among applicable HEGIS disciplines are based on a 1970-71 cost study. SCH are counted in some vocational programs, but SCH equivalents to FTE vary among these programs.

There is no local support of community colleges. Faculty workload is a local prerogative. Typically, academic faculty carry a load of 15 hours per week and the vocational faculty workload requirement is somewhat higher. Workload is an issue negotiated through collective bargaining.

West Virginia. Enrollment is a factor in the distribution of state funds to the three community colleges in West Virginia, but there is no application of a specific enrollment-driven formula. Enrollment is measured in terms of FTE, where one FTE is 15 credits per semester. Differential funding rates exist among various disciplines. There is no local contribution to help support community colleges. Faculty workload is a prerogative of the local governing boards.

Wisconsin. There is no community college system in Wisconsin. There are two-year centers operated by the University of Wisconsin and various vocational, technical, and adult education districts. The University system, including the two-year centers, is fully state supported. The vocational, technical, and adult education districts receive funds from state and local sources. Enrollment is a factor in the distribution of state aid to these districts. Enrollment is measured in terms of FTE, where one annualized FTE is 30 semester credits. No SCH measures are taken. Faculty workload is a local prerogative.

Wyoming. Enrollment is a factor in the distribution of state funds only in cases of unusual growth. Colleges compute various program cost factors and include them in their budget requests. Enrollment data are reported as full-time, part-time, and non-credit headcount figures and in terms of FTE. One FTE is 12 semester credits per term, annualized to 24. SCH are tallied in non-credit courses, but these courses are self-supporting and receive no state aid. Local support is derived from property taxes.

District property values are based on the mineral valuation. Four mills are assessed for community colleges and the state provides equalization. Systemwide, state and local sources provide 65 and 25 percent, respectively, of the support. Faculty workload is a local prerogative.

Summary

The findings indicate that, in 34 of the 42 states surveyed, enrollment is a factor in the allocation of state funds to community colleges. The remaining states utilize various negotiation procedures. All states, however, require that enrollment data be reported. Of the 34 states that utilize enrollment-dependent funding procedures, the predominant funding unit is the student credit. Nineteen states use only credits to measure enrollment. Three states use only SCH. The remaining 13 states measure enrollment through unit mixtures--10 states compute student credits and SCH while two states compute student credits, SCH, and headcount units of full-time students. Two of the major sources of community college revenue, state aid and student fees, are based on enrollment. Local support, where it exists, may only be loosely related to enrollment. By 1980, local support of community colleges was reduced to a median of 7 percent (Wattenbarger and Bibby, 1981). Twenty-eight of the 42 states apply, with varying degrees of complexity, differential funding by programs.

Faculty workload standards are, in general, prerogatives of local institutions. State-level workload provisions exist in 12 states, but more have the issue under study. A summary of the findings is presented in Table 3.

The predominant unit that generates state income to community colleges in states that base funding on enrollment is the student credit. From an economic perspective, student credits may be considered the products of a

Table 3
State Funding and Workload Provisions

State	Enrollment-Based Funding	Funding Units	Differential Funding by Program (# of Programs)	State + Student: Local Support	State-Level Workload Provisions
Alabama	Yes	Credits, SCH	No	100:0	No
Arizona	Yes	Credits	Yes (2)	55:45	No
Arkansas	Yes	Credits	Yes (N/A)[a]	N/A	No
California	Yes	SCH	Yes (2)	71:29	No
Colorado (state)	Yes	Credits, SCH	Yes (25)	100:0	No
Colorado (local)	Yes	Credits, SCH	Yes (25)	49:51[b]	No
Connecticut	No	--	Yes (N/A)	100:0	Yes[c]
Delaware	Yes	Credits	No	100:0	No
Florida	No	--	Yes (34)	100:0	Yes[d]
Georgia	Yes	Credits	Yes (N/A)	100:0[e]	Yes
Illinois	Yes	Credits, SCH	Yes (7)	58:42	No
Iowa	No	--	No	88:12	Yes
Kansas	Yes	Credits	Yes (2)	N/A	No
Kentucky	No	--	No	100:0[f]	Yes
Louisiana	Yes	Credits	Yes (N/A)	100:0	No

Notes: [a]N/A indicates data not available.

[b]Median percentages.

[c]State-level collective bargaining agreement.

[d]Local standards are subject to state retirement laws.

[e]One college receives some local support.

[f]Two colleges receive some local support.

Table 3 (continued)

State	Enrollment-Based Funding	Funding Units	Differential Funding by Program (# of Programs)	State + Student: Local Support	State-Level Workload Provisions
Maryland	Yes	Credits, SCH	No	66:34	No
Massachusetts	Yes	Credits	No	100:0	Yes[g]
Michigan	Yes	Credits	Yes (4)	75:25	No
Minnesota	Yes	Credits	Yes (3)	100:0	Yes[h]
Mississippi	Yes	Credits, SCH, headcount[i]	Yes (2)	80:20	Yes
Missouri	Yes	Credits	Yes (3)	70:30	No
Montana	Yes	Credits	No	74:26	No
Nebraska	No	--	No	62:38	No
Nevada	Yes	Credit	Yes (N/A)	100:0	No
New Hampshire	No	--	No	100.0	No
New Jersey	Yes	Credits	Yes (6)	67:33	N/A
New Mexico	Yes	Credits, SCH	Yes (9)	90:10	No
New York	Yes	Credits	Yes (3)	61:39	No
North Carolina	Yes	SCH	No	88:12	Yes

Notes: [g]State-level collective bargaining agreement.

[h]State-level collective bargaining agreement.

[i]Headcount data for full-time students (12 or more credits).

Table 3 (continued)

State	Enrollment-Based Funding	Funding Units	Differential Funding by Program (# of Programs)	State + Student: Local Support	State-Level Workload Provisions
North Dakota	No	--	No	N/A	No
Ohio	Yes	Credits	Yes (7)	N/A	No
Oklahoma	Yes	Credits	Yes (62)	100:0[j]	No
Oregon	Yes	Credits, SCH	No	53:47	No
Pennsylvania	Yes	Credits, SCH, headcount[k]	Yes (2)	67:33	No
South Carolina	Yes	Credits, SCH	Yes (25)	91:9	Yes
Tennessee	Yes	Credits	Yes (N/A)	100:0	Yes
Texas	Yes	SCH	Yes (19)	N/A	No
Utah	Yes	Credits, SCH	No	100:0	No
Virginia	Yes	Credits	Yes (N/A)	100:0	Yes
Washington	Yes	Credits, SCH	Yes (N/A)	100:0	No
West Virginia	Yes	Credits	Yes (N/A)	100:0	No
Wisconsin	No	--	No	N/A	No
Wyoming	Yes[l]	Credits, SCH	Yes (N/A)[m]	75:25	No

Notes: [j]Four colleges receive some local support.

[k]Headcount data for full-time students (12 or more credits).

[l]Enrollment is a factor only in funding growth.

[m]Program cost factors are computed locally.

community college, i.e., items that are sold to the state and the students to generate income. Productivity is the amount of production per member of the workforce, i.e., per FTEF. The productivity model can be written in the following form:

$$P = \frac{SC}{FTEF} \quad ,$$

where P is productivity, SC is the number of student credits produced, and FTEF is the number of full-time equivalent faculty.

Productivity, as represented by the formula above, is closely related to the concept of cost-effectiveness, the ratio of income to cost. College income is based on the number of funding units SC, while the major component of cost, faculty salaries, is represented by FTEF. Before the model can be fully developed, FTEF must be quantified in terms of activities that contribute to the computation of faculty workload.

The Faculty Workload Model

For the purposes of this study, the following assumptions regarding community college faculty workload are made.

1. There exists a range of faculty activities, including non-teaching activities, that contribute to workload.

2. Since different institutions have varying resources, programs, and priorities, the recognition of specific activities to be included in workload assignments is an institutional prerogative.

3. The reference standard for a full faculty load is 15 hours per week of a standard lecture/discussion class.

4. One hour per week of a "laboratory" assignment (including science laboratories, learning laboratories, shops, clinics, and physical education classes), which requires less outside preparation than one hour of

lecture/discussion, is, for workload computation purposes, equated to three-fourths of one hour per week of lecture/discussion. Thus, since $3/4 \times 20 = 15$, a full faculty load of exclusively laboratory assignments is 20 hours per week.

5. Points are assigned for all recognized activities.

6. Since 60 is the smallest whole number divisible by both 15 and 20, a full faculty load is defined to be 60 points. The exception to this standard occurs in a short term. At any level of aggregation, the number of full-time equivalent faculty (FTEF) is the total number of points (AP) assigned to that level divided by 60, i.e.,

$$FTEF = AP/60.$$

Consider a faculty member who, during a standard term, achieves a full 60-point load by teaching five three-credit lecture/discussion classes. Since $60 \div 5 = 12$, each class is a 12-point assignment. This particular arrangement meets the 15 hour per week reference standard only if one credit is awarded for each weekly contact hour; or, for workload computation, four points are awarded for each credit. During short terms, more than one weekly contact hour may be required for one credit, i.e., for four points. But the reference standard, regardless of term length, is 15 contact hours per week. During short terms, a full workload may be less than 60 points. For example, if two weekly contact hours are required for one credit, i.e., for four points, then each weekly contact hour generates two points and the full load is $15 \times 2 = 30$ points.

For the purpose of this study, one FTEF is equated to 60 points. During short terms, one FTEF generally comprises more than one full faculty load. In the example cited above, two full faculty loads constitute one FTEF.

Categories of Faculty Activities

One of the assumptions regarding faculty workload is that there exists a range of activities, including non-teaching activities, that institutions may recognize as workload components. Moreover, some teaching assignments require less preparation than others and more weekly contact hours of such assignments are required to achieve a full load. For the purpose of this study, the categories of faculty activities given in the following paragraphs are used throughout. These categories comprise the various faculty activities that were described in the literature on faculty workload. Point-to-contact hour ratios given are those for a standard term.

Presentation. Presentation refers to the category of faculty activity that occurs in a standard lecture/discussion class assignment. A normal requirement for outside preparation is assumed, but class size is not a factor. For purposes of faculty loading, one weekly presentation hour during a standard term is worth four points.

Supervision. Supervision refers to the direction of learning activities in sessions that do not carry the full burden of outside preparation normally associated with presentation. The size of the student group is not a factor. Typical assignments in this category are science laboratories, individualized or group music lessons, learning laboratories, clinics, shops, and physical education classes. For purposes of faculty loading, one weekly supervision hour during a standard term is worth three points.

Compensation. Compensation refers to additional paperwork, grading, or administrative activity generated by the form or structure of the learning arrangement. When associated with concurrent presentation or supervision, compensation is recognized only if there is a demonstrated requirement for work beyond the normal expectation. If an unusually large amount of

paperwork and grading is generated by the size of the student group, this may be recognized by the awarding of compensation points in addition to the presentation or supervision points otherwise assigned. Compensation points are computed into a faculty load as a lump sum not necessarily based on a weekly contact hours.

Management. This category comprises management activities required by job assignment. The most common example is the responsibility assumed by a department chairperson, but the coordination of a learning laboratory or some other arrangement involving a large number of students, staff, or faculty may also be regarded as management. Management points are computed into a faculty load as a lump sum that may depend on the job title and/or the size of the group managed.

Planning and Development. This category refers to the planning and development of curriculum, or of strategies or materials for the effective delivery of instruction. A certain amount of planning and development activity is assumed to be part of the outside preparation associated with any teaching assignment. Formal planning and development assignments are reserved for activities of larger scope or more complexity. The planning and development category provides institutions the opportunity to utilize faculty in adapting the curriculum to a changing environment. Planning and development may be assigned during either the conceptualization phase of an undertaking or the implementation phase. Points for planning and development are computed into a faculty load as a lump sum based on the magnitude of the task.

Sponsorship. Sponsorship refers to activities that involve regular interaction with students outside the standard curriculum. Typical sponsorship assignments are play direction, coaching, and sponsorship of

student organizations. A normal amount of outside interaction with students is expected to be part of a normal duty schedule. Points for sponsorship are awarded for activities whose demands exceed the normal expectation and are computed into a faculty load as a lump sum based on the magnitude of the task.

Service/Research. Service refers to activities that constitute service to the institution or community. Such activities include committee membership, union or faculty organization office-holding, representing the college in civic organizations, conducting short courses, and public relations activities. A certain amount of college and community service is expected as part of normal duties. Service points are awarded for activities whose demands exceed the normal expectation and are computed into a faculty load as a lump sum based on the magnitude of the task. Research refers to research activities sponsored and supported by the college or by external sources awarding grants. Research points are assigned as a lump sum based on the magnitude of the task.

Paraprofessional. A paraprofessional is an individual who provides assistance with the implementation of the instructional program. The educational credentials required of paraprofessionals are generally lower than those of faculty members. Paraprofessionals are often found in learning laboratories as well as other instructional areas. For the purpose of this study, it is assumed that a full-time paraprofessional workweek approximates a standard 40 hours. Moreover, it is assumed that the salary of a full-time paraprofessional is approximately two-thirds the average salary of full-time faculty members. Thus, 40 points per standard term are charged to an academic unit employing one full-time paraprofessional. Points for part-time paraprofessionals are determined *pro rata*.

The incorporation of compensation, management, planning and development, sponsorship, and service/research points into a faculty load as lump sums require a degree of subjectivity. The reference standard for assigning points in all these categories is presentation. The academic administrator must determine how the amount of work involved compares with that for a three-credit lecture/discussion class worth 12 points.

The elements of the productivity model

$$P = \frac{FU}{FTEF} ,$$

have been identified and quantified. The funding unit, FU, is the number of student credits produced and FTEF is quantified in terms of points. Specifically, at any level of aggregation, FTEF = AP/60, where AP is the number of points assigned to that level. The productivity model is developed in the following sections.

The Productivity Model

The productivity model is appropriate for community colleges that derive state income predominantly on the basis of the number student credits produced. The model is

$$P = \frac{SC}{FTEF} ,$$

where P is productivity, SC is the number of student credits produced, and FTEF is the number of full-time equivalent faculty. In terms of points, since FTEF = AP/60 (where AP is the number of assigned points),

$$P = \frac{SC}{AP/60} ,$$

or equivalently,

$$P = \frac{60 \times SC}{AP} .$$

The formula can be used to compute productivity at any level of aggregation.

Example 3.1. Given a standard three-credit lecture/discussion class for which the instructor earns 12 points. Suppose the class contains 30 students. Then, since 30 x 3 = 90 student credits are produced, the productivity of this class is

$$P = \frac{60 \times SC}{AP} = \frac{60 \times 90}{12} = 450.$$

Example 3.2. Suppose that, during a given term, an academic department produces 9,000 student credits and has assigned a total of 1,500 points (including teaching and non-teaching points). Then the department's productivity is

$$P = \frac{60 \times 9000}{1500} = 360.$$

At the level of aggregation of a class or a group of classes, productivity represents the number of student credits produced divided by the number of FTEF. At those levels, productivity is clearly related to class size--large classes generate more student credits than small classes. The specific mathematical forms of the relationships between productivity and class size are presented in the following sections.

Productivity and Class Size - Lecture/Discussion Classes

In special circumstances, productivity calculations can be made by shortcut methods. Moreover, it is often possible to compute productivity given data other than student credits and assigned points. In particular, the productivity of a single lecture/discussion class can be determined from the size of the class. In example 3.1, the productivity of the class is 15 times the number of students enrolled in the class, i.e., 450 = 15 x 30. In a lecture/discussion format, where only presentation points are assigned, and each weekly contact hour generates one credit, this is always the case.

Theorem 3.1. The productivity of a single lecture/discussion class, for which only presentation points are assigned to the instructor, is given by $P = 15 \times N$, where N is the number of students enrolled in the class, i.e., the class size.

Proof. Suppose the class is for k credits. Then the total number of student credits produced is $SC = N \times k$. Similarly, since presentation points are awarded at 4 points per credit, $AP = 4 \times k$. Thus:

$$\begin{aligned} P &= \frac{60 \times N \times k}{4 \times k} \\ &= \frac{60}{4} \times N \quad \text{(the k factors cancel: } \frac{k}{k} = 1) \\ &= 15 \times N. \qquad \text{(QED)} \end{aligned}$$

The equation in Theorem 3.1 applies to any class involving only presentation points and is independent of the number of student credits awarded. The productivity of a three-credit lecture/discussion class with 30 students and the productivity of a five-credit lecture/discussion class with 30 students are both $15 \times 30 = 450$. But the number of student credits awarded is a factor in the relationship between the productivity of a group of classes and average class size.

Example 3.3. Suppose a three-credit lecture/discussion class (12 points) contains 35 students and a five-credit lecture/discussion class (20 points) contains 25 students. Then the total number of student credits produced by this pair of classes is $(35 \times 3) + (25 \times 5) = 230$ and the total number of points assisgned is $12 + 20 = 32$. The productivity of the first class is $15 \times 35 = 525$ and the productivity of the second class is $15 \times 25 = 375$. The productivity of the group is

$$P = \frac{60 \times 230}{32} = 431.25.$$

Two observations are apparent:

1. The productivity of the combined pair is not the simple average of the individual productivities, and

2. Although each individual productivity is 15 times the class size, the productivity of the group is not 15 times the average class size ($15 \times 30 = 450 \neq 431.25$).

The productivity of a group of lecture/disscussion classes can be computed from the average class size provided all the classes in the group are of the same credit denomination.

Theorem 3.2. The productivity of a group of lecture/discussion classes, having the same credit denomination and for which only presentation points are assigned to the instructor(s), is given by $P = 15 \times \bar{N}$, where $\bar{N}$ is the average class size.

Proof. Suppose the group consists of n classes of k credits each with respective enrollments $N_1, N_2, \ldots, N_n$. Then

$$\bar{N} = \frac{N_1 + N_2 + \ldots + N_n}{n},$$

i.e.,

$$N_1 + N_2 + \ldots + N_n = n \times \bar{N}.$$

The number of student credits produced in the individual classes are $N_1 \times k$, $N_2 \times k, \ldots, N_n \times k$, respectively. Thus, the total number of student credits produced by the group is

$$\begin{aligned} SC &= (N_1 \times k) + \ldots + (N_n \times k) \\ &= k \times (N_1 + N_2 + \ldots + N_n) \\ &= k \times n \times \bar{N}. \end{aligned}$$

Since only presentation points are assigned, each class is worth $4 \times k$ points. Since there are n classes, the total number of points assigned is $AP = 4 \times k \times n$. Thus, the productivity of the group is given by

$$P = \frac{60 \times SC}{AP}$$

$$= \frac{60 \times k \times n \times \bar{N}}{4 \times k \times n}$$

$$= 15 \times \bar{N}. \quad \text{(QED)}$$

Productivity and Class Size - Any Instructional Arrangement

In lecture/discussion classes, four presentation points are assigned per weekly contact hour and each weekly contact hour generates one credit, i.e., the point-to-credit ratio is four. Other instructional arrangements are possible. For example

1. Three supervision points may be assigned per credit,

2. Four presentation points (or three supervision points) may be awarded for each weekly contact hour, but more than one weekly contact hour may be required to generate one credit, or

3. Points may be assigned as a mixture of presentation, supervision, and compensation points.

Theorems 3.1 and 3.2 can be generalized to any instructional arrangement, provided the point-to-credit ratio is given.

Theorem 3.3. Given an instructional arrangement in which the point-to-credit ratio is r. Then the productivity is given by

$$P = \frac{60}{r} \times N,$$

where N is the class size.

Proof. Suppose the class is for k credits. Then r = AP/k, the number of student credits produced is SC = k x N, and the productivity is

$$P = \frac{60 \times k \times N}{AP}$$

$$= 60 \times \frac{k}{AP} \times N$$

$$= \frac{60}{\left(\frac{AP}{k}\right)} \times N$$

$$= \frac{60}{r} \times N. \quad \text{(QED)}$$

Example 3.4. Given a physical education class in which 24 students earn one credit for two weekly contact hours and the instructor is assigned points at the supervision rate, i.e., three points per weekly contact hour. Then 6 points are assigned and the point-to-credit ratio is $r = 6/1 = 6$. The productivity of the class is

$$P = \frac{60}{6} \times 24 = 240.$$

Example 3.5. Given a science lab in which 24 students earn two credits for three weekly contact hours and the instructor is assigned points at the supervision rate. Then 9 points are assigned and $r = 9/2 = 4.5$. The productivity of the lab is

$$P = \frac{60}{4.5} \times 24 = 320.$$

Example 3.6. Given a three-credit lecture/discussion class containing 72 students. The instructor is assigned the usual 12 presentation points plus 6 compensation points because of the large class size. Then $r = 18/3 = 6$ and the productivity of the class is

$$P = \frac{60}{6} \times 72 = 720.$$

Theorem 3.3 can be extended to compute the productivity of a group of classes. As in the case of lecture/discussion classes, the productivity of any group of classes can be expressed in terms of average class size only if all the classes in the group have the same point-to-credit ratio and the same credit denomination.

<u>Theorem 3.4</u>. Given a group of classes with the same credit denomination and the same point-to-credit ratio r. Then the productivity of the group is given by

$$P = \frac{60}{r} \times \bar{N} ,$$

where $\bar{N}$ is the average class size.

<u>Proof</u>. Suppose the group consists of n classes of size N_1, N_2, ..., N_n, respectively. Suppose each class is for k credits. If AP_i is the number of points assigned to the ith class, i = 1, 2, ..., n, then

$$\frac{AP_i}{k} = r ,$$

i.e., $AP_i = r \times k$. Thus each class is assigned r x k points and n x r x k points are assigned to the group. Since

$$\bar{N} = \frac{N_1 + N_2 + \ldots + N_n}{n} ,$$

$N_1 + N_2 + \ldots + N_n = n \times \bar{N}$. The total number of student credits produced is given by

$$\begin{aligned} SC &= (k \times N_1) + (k \times N_2) + \ldots + (k \times N_n) \\ &= k \times (N_1 + N_2 + \ldots + N_n) \\ &= k \times n \times \bar{N}. \end{aligned}$$

The productivity of the group is

$$\begin{aligned} P &= \frac{60 \times k \times n \times \bar{N}}{n \times r \times k} \\ &= \frac{60}{r} \times \bar{N}. \qquad \text{(QED)} \end{aligned}$$

Productivity is related to class size, but the relationship is not fixed for all instructional arrangements. Theorems 3.3 and 3.4 demonstrate that productivity also depends on the point-to-credit ratio. In a lecture/discussion class, where the point-to-credit ratio is 4 and P = 15 x N, each

additional student increases productivity by 15. In a science lab, where students earn one credit for two hours per week and the instructor is assigned 6 points (two weekly hours at the supervision rate), the point-to-credit ratio is 6 and P = 10 x N. Each additional student increases productivity by 10. A group size of 30 produces a productivity of 450 in the lecture/discussion class, but only 300 in the science lab. Unless the state provides funds at a higher rate per credit for science labs, they are less cost-efficient than lecture/discussion classes.

Summary

Telephone interviews conducted with officials or staff members of the state agencies responsible for community college affairs in 42 states provided the following:

1. Enrollment is a factor in the allocation of state funds to community colleges in 34 of the 42 states, and

2. The predominant unit used to measure enrollment is the student credit.

Thus the productivity model can be written in the following form:

$$P = \frac{SC}{FTEF},$$

where P is productivity, SC is the number of student credits produced, and FTEF is the number of full-time equivalent faculty.

For the purpose of this study, faculty activities (teaching and non-teaching) are incorporated into categories. These categories are (a) presentation, (b) supervision, (c) compensation, (d) management, (e) planning and development, (f) sponsorship, (g) service/research, and (h) paraprofessional. The faculty workload model assigns points to faculty members who engage in recognized activities within each category. The presentation category represents teaching in the standard lecture/discussion

format where four points are assigned for each weekly hour of instruction Since the reference standard for a full faculty workload is 15 weekly hours of lecture/discussion, one FTEF is equated to 60 points. Thus, at any level of aggregation the number of FTEF is given by

$$\text{FTEF} = \frac{\text{AP}}{60} ,$$

where AP represents the number of assigned points.

Points in the supervision category are assigned at the rate of three per weekly hour. Points in the remaining categories are assigned as lump sums depending on the magnitudes of the tasks undertaken.

With FTEF expressed in terms of assigned points, the productivity model can be written as the formula

$$\text{P} = \frac{60 \times \text{SC}}{\text{AP}} ,$$

where P is productivity, SC is the number of student credits produced, and AP is the number of assigned points. This formula can be used to compute productivity at any level of aggregation, provided that the number of student credits and the number of assigned points are known.

There are situations in which productivity calculations can be made from data other than the number of student credits and the number of assigned points. In particular, the productivity of a single class can be calculated from the class size and the productivity of a group of classes, each having the same point-to-credit ratio and the same credit denomination, can be calculated from the average class size. The following theorems apply:

Theorem 3.1. The productivity of a single lecture/discussion class, for which only presentation points are assigned, is given by $P = 15 \times N$, where N is the class size.

Theorem 3.2. The productivity of a group of lecture/discussion classes, having the same credit denomination and for which only presentation points are assigned, is given by $P = 15 \times \bar{N}$, where $\bar{N}$ is the average class size.

Theorem 3.3. The productivity of an instructional arrangement, in which the point-to-credit ratio is r, is given by

$$P = \frac{60}{r} \times N \quad ,$$

where N is the class size.

Theorem 3.4. The productivity of a group of classes, having the same credit denomination and the same point-to-credit ratio r, is given by

$$P = \frac{60}{r} \times \bar{N} \quad ,$$

where $\bar{N}$ is the average class size.

The productivity equations presented in this chapter enable academic administrators to obtain feedback from academic units. The remainder of this study focuses on applications of the productivity model as a feedforward control system. The purpose is to demonstrate that productivity can be managed.

CHAPTER IV

MANAGEMENT OF PRODUCTIVITY

In community colleges that derive state income on the basis of enrollment units, the "products" or "outputs" are those units. Productivity measures the number of units produced per member of the workforce, i.e., per FTEF. Moreover, since the major component of a community college's costs is associated with faculty salaries, productivity is a measure of cost-effectiveness, the ratio of income to cost. As with any enterprise that derives income and incurs costs, a community college must achieve a certain level of productivity in order to maintain financial stability.

In this chapter, discussion focuses on applications of the productivity model

$$P = \frac{60 \times SC}{AP},$$

where P is productivity, SC is the number of student credits produced, and AP is the number of faculty workload points associated with the student credits produced. It is assumed that income is student-credit dependent. A summary of previously established theorems that pertain to the productivity model and relate productivity to class size is given below.

Theorem 3.1. The productivity of a single lecture/discussion class, for which only presentation points are assigned, is given by $P = 15 \times N$, where N is the class size.

Theorem 3.2. The productivity of a group of lecture/discussion classes, having the same credit denomination and for which only presentation points are assigned, is given by $P = 15 \times \bar{N}$, where $\bar{N}$ is the average class size.

Theorem 3.3. The productivity of an instructional arrangement, in which the point-to-credit ratio is r, is given by

$$P = \frac{60}{r} \times N,$$

where N is the class size.

Theorem 3.4. The productivity of a group of classes, having the same credit denomination and the same point-to-credit ratio r, is given by

$$P = \frac{60}{r} \times \bar{N},$$

where $\bar{N}$ is the average class size.

From a management perspective, the productivity equations

$$P = \frac{60 \times SC}{AP},$$

$$P = 15 \times N,$$

$$P = 15 \times \bar{N},$$

$$P = \frac{60}{r} \times N,$$

and

$$P = \frac{60}{r} \times \bar{N},$$

are useful only because they provide feedback. As written, these equations cannot be used by academic administrators to manage, i.e., control, productivity.

The purpose of this chapter is to demonstrate how productivity can be managed before learning activities occur, i.e., how the productivity model can be adapted to serve as a feedforward control system. At the level of aggregation of a single class or a group of classes with the same point-to-credit ratio, productivity can be controlled by the utilization of

enrollment projections, productivity targets, and alternate forms of the productivity equations. At higher levels of aggregation, such as the department level and the campus level, productivity can be controlled by the utilization of enrollment projections, productivity targets, subset productivity, and gaming. All of these concepts are presented in the following sections.

Enrollment Projections

It is possible to predict enrollment. Predictions are based on applications of various projection models, most of which are computerized. A projection model applies time-series analysis methods to historical data and then determines a confidence interval which, with a specified level of probability, provides a range of projected student credits. For example, the model may predict that, with a 95 percent probability, the number of student credits produced during a given (future) term at a college will be between 105,000 and 106,000. The midpoint of the interval (105,500) is an adequate projection with which to plan programs.

The reliability of a projection model depends on the validity of the input, i.e., the historical data. Historical data include long-term growth and decline patterns, historical term-by-term adjustments, and other phenomena. In general, the closer to the beginning of the targeted term or year that a projection model is applied, the smaller the confidence interval will be, i.e., the more accurate the projection. For a projection model, recent history is more significant than remote history. For this reason, projection models may be applied as many as four or five times prior to the beginning of a targeted term. The initial projection is generally made six to eight months in advance.

In general, a projection model predicts a range of student credits campuswide. Predicting how these credits will be distributed among the various departments is the responsibility of administrators and staff. The single constraint in this process is that the sum of the predicted credits distributed must equal the campuswide projection provided by the model (Catherine Morris, personal interview, July 7, 1983).

Productivity Targets

For the purpose of this study, it is assumed that productivity targets are set for a campus and for each of its departments. Ideally, the campus productivity target is economically acceptable and assures financial stability. Ideally, each department's target is pedagogically acceptable and assures effective instruction. Thus, the campus target must be "high enough" while each department's target must be "low enough." Since campus productivity is a function of its departments' productivities, the economic and pedagogical considerations produce a conflict that is not always easy to resolve.

The initial setting of productivity targets can be achieved by investigating the recent and/or current state of affairs, i.e., by computing historical and/or existing campus and department productivities from the student credits produced and the points assigned. There are two cases to consider.

First, if the campus is in a state of financial stability, then the productivities calculated may become the preliminary targets. If these are satisfactory to all concerned, then the preliminary targets may serve as the assigned targets. If one or more given departments can demonstrate that extenuating circumstances during the term, or terms, that productivities were investigated resulted in higher-than-pedagogically-desirable targets,

then adjustments may have to be made. Either the campus target must be lowered or other departments' targets must be raised in order to accommodate the lower targets of the given departments.

Second, if the campus is not financially stable, then the campus must either find ways to reduce costs or determine a productivity level that would assure financial stability (or both). If the campus target is to be raised, then one or more of the department targets must also be raised.

Alternate Forms of Productivity Equations

At any level of aggregation, the productivity model

$$P = \frac{60 \times SC}{AP}$$

provides feedback information but does not enable managers to control productivity. When combined with enrollment projections and productivity targets, an alternate form of the model allows managers to control productivity by controlling the number of assigned points.

Corollary 4.1. Given a projected number of student credits SC and a productivity target P. Then the number of workload points, AP, necessary to achieve the target is given by

$$AP = \frac{60 \times SC}{P} .$$

Proof. Consider the equation that represents the productivity model, i.e.,

$$P = \frac{60 \times SC}{AP} .$$

Multiply both sides by the factor AP and obtain

$$P \times AP = 60 \times SC.$$

Divide both sides of this equation by P and obtain

$$AP = \frac{60 \times SC}{P} . \quad \text{(QED)}$$

Problem 4.1. How many points must a department chairperson assign during a given term if 6,000 credits are projected and the department must achieve a productivity of at least 450?

Solution. If P = 450 and SC = 6000, then

$$AP = \frac{60 \times 6000}{450} = 800.$$

Assigning exactly 800 points results in an achieved productivity of exactly 450. Given a fixed number of student credits, P and AP are inversely proportional, i.e., as AP decreases, P increases. Conversely, as AP increases, P decreases. If the department is to achieve a productivity of at least 450, the chairperson may assign at most 800 points.

Corollary 4.2. Given a projected number of student credits SC and a productivity target P. Then the number of FTEF required achieve the target is given by

$$FTEF = \frac{SC}{P} .$$

Proof. By Theorem 4.1,

$$AP = \frac{60 \times SC}{P} .$$

But FTEF = AP/60, i.e., $AP = 60 \times FTEF$. Thus

$$60 \times FTEF = \frac{60 \times SC}{P} .$$

Divide both sides of this equation by 60 and obtain

$$\text{FTEF} = \frac{SC}{P} . \qquad \text{(QED)}$$

Problem 4.2. During a given term, the number of credits projected for a campus is 90,000. How many full-time faculty members must the campus employ if (a) the campus productivity target is 400 and (b) the number of full-time faculty members can be at most 80 percent of FTEF, where the remaining 20 percent or more of projected need is to be assigned either to full-time faculty members as "overload" or to part-time faculty members?

Solution. If SC = 90,000 and P = 400, then

$$\text{FTEF} = \frac{90{,}000}{400} = 225.$$

The number of full-time faculty members required is at most 80 percent of 225, i.e., at most 180.

At the level of aggregation of a single class or a group of classes with the same credit denomination and point-to-credit ratio, productivity can be controlled by controlling class size.

Corollary 4.3. Given a lecture/discussion class in which only presentation points are assigned. Then the number of students in the class, i.e., class size, required to achieve a productivity target of P is given by

$$N = \frac{P}{15} .$$

Proof. By Theorem 3.1, the productivity of the class is P = 15 x N. Divide both sides of the equation by 15 and obtain

$$N = \frac{P}{15} . \qquad \text{(QED)}$$

Corollary 4.4. Given a group of lecture/discussion classes for which only presentation points are assigned. Then, in order for the group to achieve a productivity target of P, the average class size must be

$$\bar{N} = \frac{P}{15} .$$

Proof. By Theorem 3.2, the productivity of the group is $P = 15 \times \bar{N}$. Thus

$$\bar{N} = \frac{P}{15} . \quad \text{(QED)}$$

Problem 4.3. What must be the average size of a group of lecture/ discussion classes in order for the group to achieve a productivity of at least 393?

Solution. Since P = 393,

$$\bar{N} = \frac{393}{15} = 26.2 .$$

The average class size must be at least 26.2.

Corollary 4.5. Given an instructional arrangement in which the point-to-credit ratio is r. Then the number of students required to achieve a productivity target of P is given by

$$N = \frac{P \times r}{60} .$$

Proof. By Theorem 3.3,

$$P = \frac{60}{r} \times N.$$

Solving for N,

$$N = \frac{P \times r}{60} . \quad \text{(QED)}$$

Corollary 4.6. Given a group of instructional arrangements with the same credit denomination and the same point-to-credit ratio r. Then, in order to achieve a productivity target of P, the average class size must be

$$\bar{N} = \frac{P \times r}{60} .$$

Proof. By Theorem 3.4

$$P = \frac{60}{r} \times \bar{N}.$$

Solving for $\bar{N}$,

$$\bar{N} = \frac{P \times r}{60} . \quad \text{(QED)}$$

Problem 4.4. Given a group of 2-credit chemistry labs for which instructors are assigned 9 supervision points for three weekly contact hours. What must be the average size of the labs if the group is to achieve a productivity of 300?

Solution. Since P = 300 and r = 9/2 = 4.5,

$$\bar{N} = \frac{300 \times 4.5}{60} = 22.5.$$

The average size of the labs must be 22.5.

One way for a campus to achieve its productivity target is to assign that same target to each department. For purposes of effective instruction and workload equity, it may be unreasonable to make such uniform productivity assignments. In the area of developmental education, it is possible that effective instruction can occur only if students are provided a great deal of individualized attention. Therefore the average class size, and hence productivity, should be relatively low. In English classes, where

several writing assignments may be required and the paper-grading burden on teachers is relatively high, the average class size, and hence productivity, should be relatively low. In physical education, the number of non-teaching (released) points assigned for coaching duties may be relatively high. Moreover, the points assigned to the classes are assigned at the supervision rate. Even with relatively high average class size, productivity in physical education is relatively low. Science labs may have relatively few student stations available. Moreover, the number of students in a science lab may, for safety reasons, be relatively low. Therefore, the productivity of science departments would be relatively low.

In order to maintain financial stability, a campus must maintain a specified level of productivity. But, for various reasons, some departments may be assigned targets lower than the campus target. Therefore, other departments would necessarily maintain a productivity level higher than the campus target. The relationship between a single campus productivity and the various department productivities is found in the concept of subset productivity. Subset productivity, in fact, specifies the relationship between productivity at any level of aggregation and the corresponding productivities at sublevels.

Subset Productivity

A set is any collection of objects. The objects in a set are called its elements. Sets are named by capital letters or by subscripted capital letters. A set S_1 is called a subset of S if every element in S_1 is also in S. Two sets S_1 and S_2 are called disjoint if they have no common elements. A collection of sets S_1, S_2, ..., S_n is called pairwise disjoint if any two sets of the collection are disjoint. Given a set S, a collection of subsets S_1, S_2, ..., S_n of S is said to be exhaustive if every element of S is in at least one subset S_i of the collection. A partition of a set S

is a collection of exhaustive, pairwise disjoint subsets of S (Apostol, 1957). S is called the parent set. A partition of a set S into subsets $S_1, S_2, \ldots, S_n$ is represented in Figure 1.

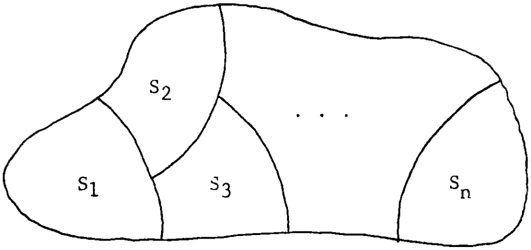

Figure 1. A Partition of a Set.

For the purpose of this study, it is necessary to consider partitions at two levels of aggregation in a community college. First, the entire academic program of a campus can be partitioned by departments $D_1, D_2, \ldots D_n$. Associated with each department D_i are a number of student credits produced (SC_i), a number of assigned points (AP_i), and a productivity P_i, where

$$P_i = \frac{60 \times SC_i}{AP_i}.$$

If SC and AP are the number of student credits produced and the number of points assigned, respectively, throughout the entire academic program of the campus,

then

$$SC = SC_1 + SC_2 + \ldots + SC_n,$$

and

$$AP = AP_1 + AP_2 + \ldots + AP_n.$$

The points assigned in a department may comprise teaching points and released points. Teaching points are those associated with instruction,

i.e., activities that produce student credits. Teaching points derive from presentation, supervision, and compensation. Moreover, if the activities of a paraprofessional generate student credits, then the points assigned to that individual are considered teaching points. Released points are those assigned in the categories of management, planning and development, sponsorship, and service/research. Moreover, if the activities of a paraprofessional do not generate student credits, then the points assigned to that individual are released points. If, in a department D_i, AP_i is the number of points assigned, TP_i is the number of teaching points assigned, and RP_i is the number of released points assigned, then

$$AP_i = TP_i + RP_i.$$

The second type of partition occurs when the set of offerings (courses) of a single department is partitioned into homogeneous groups. A homogeneous group of courses is one in which (a) all the courses have the same credit denomination, (b) all the courses have the same point-to-credit ratio, and (c) all the courses have approximately the same average class size. One additional subset in the partition of a department is the portion of the program that does not generate credits, i.e., those activities for which only released points are assigned. Suppose a department is partitioned into groups G_0, G_1, ..., G_m, where G_0 is the non-teaching portion of the program to which released points are assigned, and G_1, ..., G_m are homogeneous groups of courses. Associated with each group G_i are a number of students credits produced (SC_i), a number of points assigned (AP_i), and a productivity P_i, where

$$P_i = \frac{60 \times SC_i}{AP_i} .$$

Clearly, for the non-teaching activities G_0, $SC_0 = 0$, $P_0 = 0$, and $AP_0 = RP$, the total number of released points assigned in the department.

If a parent set is partitioned into subsets, then to each subset there corresponds a number of student credits and a number of assigned points. The productivity of the parent set can be expressed in terms of these quantities.

Theorem 4.1. Let S be a given level of aggregation and let S_1, S_2, ..., S_n form a partition of S. For each i = 1, 2, ..., n, let

(a) SC_i be the number of student credits produced in the subset S_i, and

(b) AP_i be the number of points assigned in the subset S_i.

Then the productivity, P, of the parent set S is given by

$$P = \frac{60 \times (SC_1 + SC_2 + \ldots + SC_n)}{AP_1 + AP_2 + \ldots + AP_n} .$$

Proof. Since the subsets S_1, S_2, ..., S_n form a (pairwise disjoint and exhaustive) partition of S, the total number of student credits, SC, produced by S and the total number of points, AP, assigned in S are given by

$$SC = SC_1 + SC_2 + \ldots + SC_n$$

and

$$AP = AP_1 + AP_2 + \ldots + AP_n .$$

Thus the productivity of S is given by

$$P = \frac{60 \times SC}{AP}$$

$$= \frac{60 \times (SC_1 + SC_2 + \ldots + SC_n)}{AP_1 + AP_2 + \ldots + AP_n}. \qquad \text{(QED)}$$

If a campus is partitioned into departments $D_1, D_2, \ldots, D_n$ having respective productivities $P_1, P_2, \ldots, P_n$, then each P_i $(i = 1,2, \ldots, n)$ is called a <u>subset productivity</u>. Similarly, if a department is partitioned into homogeneous groups $G_0, G_1, \ldots, G_m$ having respective productivities $P_0 = 0, P_1, \ldots, P_m$ then each P_i $(i = 0, 1, \ldots, m)$ is called a <u>subset productivity</u>. As demonstrated in the following sections, the productivity of a campus is a "weighted average" of its subset (department) productivities, and the productivity of a department is, in turn, a "weighted average" of it subset (homogeneous-group) productivities.

<u>The Weighted Average</u>

The <u>arithmetic average</u> of the n numbers $y_1, y_2, \ldots, y_n$ is given by

$$\bar{y} = \frac{y_1 + y_2 + \ldots + y_n}{n}.$$

But in averaging quantities it is often necessary to account for the fact that not all of them are equally important in the phenomenon being described. The arithmetic average attributes the same importance to each of the quantities. Consider the example presented by Freund (1978):

> In 1975 the average annual cost of heating and cooling a home was \$885.89 in Philadelphia, \$688.80 in Houston, and \$1,044.91 in Concord, Mass. . . . The [arithmetic] mean of these three figures is \$873.20, but we cannot very well say that this is the average annual cost of operating a heat pump in . . . these cities. The three figures do not carry equal weight[s] because there are not equally many heat pumps used to heat and cool homes in these cities. (p. 38)

In order to give quantities being averaged their proper degrees of importance, it is necessary to assign to each a measure of relative importance called a <u>weight</u> or a <u>weight factor</u> and then calculate the weighted average. Specifically, the <u>weighted average</u>, $\bar{y}_w$, of the n numbers $y_1, y_2, \ldots, y_n$, whose relative importances are expressed numerically by a corresponding set of weight factors $w_1, w_2, \ldots, w_n$, respectively, is given by

$$\bar{y}_w = \frac{(w_1 \times y_1) + (w_2 \times y_2) + \ldots +(w_n \times y_n)}{w_1 + w_2 + \ldots + w_n} .$$

If all the weight factors are equal, say $w_1 = w_2 = \ldots w_n = w$, then the weighted average

$$\bar{y}_w = \frac{(w \times y_1) + (w \times y_2)+ \ldots +(w \times y_n)}{w + w + \ldots + w}$$

$$= \frac{w \times (y_1 + y_2 + \ldots + y_n)}{n \times w}$$

$$= \frac{y_1 + y_2 + \ldots + y_n}{n},$$

the ordinary arithmetic average.

If a campus is partitioned into its department subsets, then the campus productivity is a weighted average of its subset productivities. Similarly, if a department is partitioned into its homogeneous-group subsets, then the department productivity is a weighted average of its subset productivities. In each case, the weight factors are the numbers of points assigned to the subsets.

<u>Productivity as a Weighted Average</u>

<u>Theroem 4.2</u>. Let S be a given level of aggregation and let S_1, S_2, ..., S_n form a partition of S. For each i = 1,2, ..., n, let

(a) P_i be the (subset) productivity of S_i, and

(b) AP_i be the number of points assigned in the subset S_i.

Then the productivity, P, of S is given by

$$P = \frac{(AP_1 \times P_1)+(AP_2 \times P_2)+ \ldots +(AP_n \times P_n)}{AP_1 + AP_2 + \ldots + AP_n}.$$

<u>Proof</u>. For each i = 1, 2, ..., n, let SC_i be the number of credits produced by the subset S_i. Then

$$P_i = \frac{60 \times SC_i}{AP_i},$$

i.e.,

$$60 \times SC_i = AP_i \times P_i.$$

By Theorem 4.1, the productivity of S is given by

$$P = \frac{60 \times (SC_1 + SC_2 + \ldots + SC_n)}{AP_1 + AP_2 + \ldots + AP_n}.$$

Thus

$$P = \frac{(60 \times SC_1)+(60 \times SC_2)+ \ldots +(60 \times SC_n)}{AP_1 + AP_2 + \ldots + AP_n}$$

$$= \frac{(AP_1 \times P_1)+(AP_2 \times P_2)+\ldots+(AP_n \times P_n)}{AP_1 + AP_2 + \ldots + AP_n}. \qquad \text{(QED)}$$

Problem 4.5. Suppose a department is partitioned into homogeneous groups G_0, G_1, G_2, where G_0 is the non-teaching program (management, planning and development, sponsorship, and service/research activities), G_1 consists of all 3-credit lecture/discussion courses, and G_2 consists of all 5-credit lecture/discussion courses. Suppose points are distributed as follows: $AP_0 = 48$, $AP_1 = 1200$, and $AP_2 = 400$. Suppose the average size of the 3-credit classes is $\bar{N}_1 = 35.2$ and the average size of the 5-credit classes is $\bar{N}_2 = 28.6$. What is the department's productivity?

Solution. Clearly, $P_0 = 0$. By Theorem 3.2, $P_1 = 15 \times 35.2 = 528$ and $P_2 = 15 \times 28.6 = 429$. By Theorem 4.2, the department's productivity is given by

$$P = \frac{(48 \times 0) + (1200 \times 528) + (400 \times 429)}{48 + 1200 + 400}$$

$$= \frac{0 + 633{,}600 + 171{,}600}{1648}$$

$$= \frac{805{,}200}{1648}$$

$$= 488.6.$$

If the number of points distributed to each of the subsets of a partitioned set are unknown, the productivity of the parent set can still be derived from the subset productivities provided the proportions of total points assigned to the subsets are known.

Corollary 4.7. Let S be a given level of aggregation and let S_1, S_2, ..., S_n form a partition of S. For each i = 1, 2, ..., n, let

(a) P_i be the (subset) productivity of S_i, and

(b) a_i be the proportion of the total points in S assigned to S_i $(0 \leq a_i \leq 1)$.

Then the productivity, P, of S is given by

$$P = (a_1 \times P_1)+(a_2 \times P_2)+ \dots +(a_n \times P_n).$$

Proof. For each i = 1, 2, ..., n, let AP_i denote the (not necessarily known) number of points assigned in the subset S_i. Then

$$a_i = \frac{AP_i}{AP_1 + AP_2 + \dots + AP_n}.$$

By Theorem 4.7,

$$P = \frac{(AP_1 \times P_1) + (AP_2 \times P_2) + \dots + (AP_n \times P_n)}{AP_1 + AP_2 + \dots + AP_n}$$

$$= \frac{AP_1 \times P_1}{AP_1 + AP_2 + \dots + AP_n} + \frac{AP_2 \times P_2}{AP_1 + AP_2 + \dots + AP_n} +$$

$$\dots + \frac{AP_n \times P_n}{AP_1 + AP_2 + \dots + AP_n}$$

$$= \left(\frac{AP_1}{AP_1 + AP_2 + \dots + AP_n} \times P_1\right) + \left(\frac{AP_2}{AP_1 + AP_2 + \dots + AP_n} \times P_2\right) +$$

$$\dots + \left(\frac{AP_n}{AP_1 + AP_2 + \dots + AP_n} \times P_n\right)$$

$$= (a_1 \times P_1)+(a_2 \times P_2)+ \dots + (a_n \times P_n). \quad \text{(QED)}$$

In the notation of the previous therorem, $a_1 + a_2 + \ldots + a_n = 1$. Therefore, if any n - 1 values of $a_1, a_2, \ldots, a_n$ are known, the remaining value can be obtained by subtracting the sum of the n - 1 known values from 1.

Problem 4.6. A department chairperson partitions the department into five homogeneous groups G_0, G_1, G_2, G_3, G_4. Historically, the percentage of total points assigned to the groups are 2 percent, 18 percent, 30 percent, 40 percent, and 10 percent, respectively (sum = 100 percent). If the subset productivities are 0, 400, 480, 380, and 300, respectively, what is the expected productivity of the department?

Solution. By Corollary 4.7,

$$\begin{aligned} P &= (.02 \times 0)+(.18 \times 400)+(.30 \times 480)+(.40 \times 380)+(.10 \times 300) \\ &= 0 + 72 + 144 + 152 + 3 \\ &= 371. \end{aligned}$$

The standard partition of a campus' academic program is into departments. In turn, the standard partition of a department's program is into homogeneous groups of courses together with the non-teaching component. However, the calculation of parent-set productivity as a weighted average of subset productivities holds when any level of aggregation is partitioned into any collection of pairwise disjoint, exhaustive subsets. If a program is partitioned into its teaching component and its non-teaching component, it is possible to compute the "instructional productivity" of the program.

Instructional Productivity

Suppose a given level of aggregation S is partitioned into subsets S^* and S_0, where S^* is the teaching component of S, i.e., those activities that generate student credits, and S_0 is the non-teaching component of S, i.e.,

those activities to which points are assigned but from which no student credits are produced. The points assigned to S^* are the teaching points, TP, and the points assigned to S_0 are the released points, RP. If AP is the total number of points assigned to the parent set S, then AP = TP + RP. The number of student credits, SC, produced by the parent set S are, in fact, those produced by S^* alone. The productivity P^* of the teaching component S^* is called the <u>instructional productivity</u> of S, and

$$P^* = \frac{60 \times SC}{TP} .$$

Suppose that a given level of aggregation has a productivity target P and that a portion of its points are assigned as released points. If the target is to be achieved, then its instructional productivity P^* must, in fact, exceed P.

<u>Theorem 4.3</u>. Let S be any level of aggregation such that P is the productivity of S, P^* is the instructional productivity of S, AP is the total number of points assigned in S, and TP is the number of teaching points assigned in S. Then

$$P = \frac{TP}{AP} \times P^* \text{ and } P^* = \frac{AP}{TP} \times P.$$

<u>Proof</u>. Partition S into its teaching component S^* and its non-teaching component S_0. The number of points assigned to S^* is TP, the number of points assigned to S_0 is RP (the number of released points), and AP = TP + RP. The subset productivities of S^* and S_0 are P^* and P_0, respectively. Since S_0 produces no student credits, $P_0 = 0$. By Theorem 4.2,

$$P = \frac{(TP \times P^*) + (RP \times 0)}{TP + RP} ,$$

i.e.,

$$P = \frac{TP \times P^*}{AP}$$

$$= \frac{TP}{AP} \times P^*.$$

Solving this equation for P*,

$$P^* = \frac{AP}{TP} \times P. \quad \text{(QED)}$$

Since AP = TP + RP, TP = AP - RP. Thus the equations of Theorem 4.3 can be written as

$$P = \frac{AP - RP}{AP} \times P^* \quad \text{and} \quad P^* = \frac{AP}{AP-RP} \times P.$$

Problem 4.8. Suppose the productivity target of a department is 425. Suppose that of 900 total points to be assigned, 42 are to be released points for management and curriculum projects. What productivity must the teaching component achieve if the department is to achieve its target?

Solution. This problem asks for the instructional productivity P*. The target is P = 425 and TP = AP - RP = 900 - 42 = 858. Thus

$$P^* = \frac{900}{858} \times 425 = 445.8.$$

The instructional component must achieve a productivity of 445.8.

Problem 4.9. A department's instructional program consists of all 3-credit lecture/discussion classes. During a given term, the average class size is $\overline{N} = 27.5$ and 8 percent of all the points assigned are released points. What is the department's productivity?

Solution. By Theorem 3.2, P* = 15 x 27.5 = 412.5. Since 8 percent of AP is RP, 92 percent of AP is TP, i.e.,

$$\frac{TP}{AP} = .92.$$

Thus the department's productivity is

$$P = .92 \times 412.5 = 379.5.$$

Productivity and Subset Credits

Theorem 4.2 demonstrates that parent-set productivity can be computed from subset productivities and subset points. When enrollment projections are made, student credits, not points, are distributed among departments. Parent-set productivity can also be computed from subset productivities and subset credits.

Theorem 4.4. Let S be a given level of aggregation and let S_1, S_2, ..., S_n form a partition of S. For each i = 1, 2, ..., n, let

(a) P_i be the productivity of S_i ($P_i \neq 0$) and

(b) SC_i be the number of student credits produced by S_i.

Let $SC = SC_1 + SC_2 + \ldots + SC_n$, the total number of student credits produced by S. Then the productivity, P, of S is given by

$$P = \frac{SC}{\left(\frac{SC_1}{P_1}\right) + \left(\frac{SC_2}{P_2}\right) + \ldots + \left(\frac{SC_n}{P_n}\right)}.$$

Proof. For each i = 1, 2, ..., n,

$$P_i = \frac{60 \times SC_i}{AP_i}.$$

Thus,

$$AP_i \times P_i = 60 \times SC_i$$

and

$$AP_i = \frac{60 \times SC_i}{P_i}.$$

By Theorem 4.2, the productivity of the parent set S is given by

$$P = \frac{(AP_1 \times P_1) + (AP_2 \times P_2) + \ldots + (AP_n \times P_n)}{AP_1 + AP_2 + \ldots + AP_n}$$

$$= \frac{(60 \times SC_1) + (60 \times SC_2) + \ldots + (60 \times SC_n)}{\left(\frac{60 \times SC_1}{P_1}\right) + \left(\frac{60 \times SC_2}{P_2}\right) + \ldots + \left(\frac{60 \times SC_n}{P_n}\right)}$$

$$= \frac{60 \times (SC_1 + SC_2 + \ldots + SC_n)}{60 \times \left(\frac{SC_1}{P_1} + \frac{SC_2}{P_2} + \ldots + \frac{SC_n}{P_n}\right)}$$

$$= \frac{SC}{\left(\frac{SC_1}{P_1}\right) + \left(\frac{SC_2}{P_2}\right) + \ldots + \left(\frac{SC_n}{P_n}\right)} . \qquad \text{(QED)}$$

If one of the subsets in a partition of a parent set S is a non-teaching component, then Theorem 4.4 cannot be used to compute the productivity of S. The theorem specifies productivity in terms of subset productivities that appear as fraction denominators. If, for some i, $P_i = 0$, as is the case for the non-teaching component, then the fraction SC_i/P_i is undefined. The theorem can be applied, however, to compute instructional productivity. For example, suppose a department is partitioned into the subsets G_0, G_1, ..., G_m, where G_0 is the non-teaching component in which all released points are assigned, and G_1, ..., G_m are homogeneous groups of courses in which only teaching points are assigned. If, for each i = 0, 1, ..., m, P_i is the productivity of G_i and SC_i is the number of student credits produced in G_i, then $SC_0 = 0$ and $P_0 = 0$. The instructional productivity of the department is

$$P^* = \frac{SC}{\left(\frac{SC_1}{P_1}\right) + \ldots + \left(\frac{SC_m}{P_m}\right)} .$$

Corollary 4.8. Let S be a given level of aggregation and let S_1, S_2, ..., S_n form a partition of S. For each i = 1, 2, ..., n, let

(a) P_i be the productivity of S_i ($P_i \neq 0$), and

(b) c_i be the proportion of the total student credits that are produced in S_i ($0 < c_i \leq 1$).

Then the productivity, P, of S is given by

$$P = \frac{1}{\left(\frac{c_1}{P_1}\right) + \left(\frac{c_2}{P_2}\right) + \ldots + \left(\frac{c_n}{P_n}\right)} .$$

Proof. For each i = 1, 2, ..., n, let SC_i be the (not necessarily known) number of student credits produced by the subset S_i, $SC_i > 0$. Let $SC = SC_1 + SC_2 + \ldots + SC_n$. Then $c_i = SC_i/SC$ and, by Theorem 4.4,

$$P = \frac{SC}{\left(\frac{SC_1}{P_1}\right) + \left(\frac{SC_2}{P_2}\right) + \ldots + \left(\frac{SC_n}{P_n}\right)}$$

$$= \frac{\left(\frac{SC}{SC}\right)}{\frac{\left(\frac{SC_1}{SC}\right)}{P_1} + \frac{\left(\frac{SC_2}{SC}\right)}{P_2} + \ldots + \frac{\left(\frac{SC_n}{SC}\right)}{P_n}}$$

$$= \frac{1}{\left(\frac{c_1}{P_1}\right) + \left(\frac{c_2}{P_2}\right) + \ldots + \left(\frac{c_n}{P_n}\right)} . \qquad \text{(QED)}$$

Problem 4.10. A science department's instructional program consists of the homogeneous groups G_1, G_2, and G_3. G_1 is a group of 3-credit lecture/discussion classes with an average class size of $\overline{N}_1 = 34.5$. G_2 is a group of 5-credit lecture/discussion classes with an average class size of $\overline{N}_2 = 27.8$. G_3 is a group of one-credit labs for which instructors are assigned 6 points and which have an average class size of $\overline{N}_3 = 21.4$. The percentages of the department's credits produced by G_1, G_2, and G_3 are 60 percent, 30 percent, and 10 percent, respectively. What is the department's instructional productivity?

Solution. By Theorem 3.2, $P_1 = 15 \times 35.5 = 517.5$ and $P_2 = 15 \times 27.8 = 417$. For the group G_3, the point-to-credit ratio is $r = 6/1 = 6$. Thus, by Theorem 3.4,

$$P_3 = \frac{60}{6} \times 21.4 = 10 \times 21.4 = 214.$$

Since $c_1 = .6$, $c_2 = .3$, and $c_3 = .1$, the department's instructional productivity is given by

$$P^* = \frac{1}{\left(\frac{.6}{517.5}\right) + \left(\frac{.3}{417}\right) + \left(\frac{.1}{214}\right)}$$

$$= 426.2.$$

The Fundamental Question

The theorems that pertain to the concept of subset productivity demonstrate how parent-set productivity can be computed from given subset productivities. By themselves, the theorems do not provide the means for controlling productivity. Managers can, however, maintain control over parent-set productivity by controlling subset productivities.

The manager of a partitioned level of aggregation achieves control of productivity when he/she can answer the following question.

The fundamental question. Given a level of aggregation S that is partitioned into subsets S_1, S_2, ..., S_n. Suppose S has a productivity target P. What can the subset productivities P_1, P_2, ..., P_n be so that the parent-set productivity P is achieved? The answer to the fundamental question is found when the subset productivity theorems are combined with the concept of "gaming."

Gaming To Achieve Parent-Set Productivity

Giving a mathematical statement that involves one or more variables. The variables are said to be gamed when a value is assigned to each variable and the resulting mathematical statement is true. A set of values assigned to the variables which result in a true statement is said to satisfy the original statement, and the set of values is called a solution of the statement.

Consider the algebraic equation $2 \times T = 10$. The variable is T and it can be gamed in only one way. T must equal 5 since any other value does not satisfy the equation. The equation has one solution.

Consider the algebraic equation $(2 \times T_1) + T_2 = 15$. The variables are T_1 and T_2, and many solutions exist. The variables can be gamed by assigning values arbitrarily to one of the variables, say T_1, and then calculating the required value of the other variable. The equation can be written in the equivalent form $T_2 = 15 - (2 \times T_1)$. If $T_1 = 4$, then $T_2 = 15 - (2 \times 4) = 15 - 8 = 7$. If $T_1 = 6$, then $T_2 = 15 -(2 \times 6) = 3$. If fractions and/or negative numbers are allowed as possible values for the variables, then the equation has infinitely many solutions, i.e., gaming can occur in infinitely many ways. Any finite number of solutions can be written in the form of a table. Table 4 presents five solutions.

Table 4
Five Solutions of $(2 \times T_1) + T_2 = 15$

T_1	T_2
1	13
3	9
4	7
6	3
7	1

At the level of aggregation of a campus, parent-set productivity can be written as one of several equations that involve any two of the following variables: subset credits, subset points, and subset productivities. The equation involving subset credits and subset points is

$$P = \frac{60 \times (SC_1 + SC_2 + \ldots + SC_n)}{AP_1 + AP_2 + \ldots + AP_n}.$$

The equation involving subset credits and subset productivities is

$$P = \frac{SC_1 + SC_2 + \ldots + SC_n}{\left(\frac{SC_1}{P_1}\right) + \left(\frac{SC_2}{P_2}\right) + \ldots + \left(\frac{SC_n}{P_n}\right)}.$$

The equation involving subset points and subset productivities is

$$P = \frac{(AP_1 \times P_1) + (AP_2 \times P_2) + \ldots + (AP_n \times P_n)}{AP_1 + AP_2 + \ldots + AP_n}.$$

At the level of aggregation of a department, one additional variable, subset average class size, may be used. Subsets are homogeneous groups of courses. If, for the ith subset, r_i is the point-to-credit ratio, $\overline{N}_i$ is the average subset class size, and P_i is the subset productivity, then, by Theorem 3.4,

$$P_i = \frac{60}{r_i} \times \bar{N}_i \ .$$

Thus, for example, parent-set productivity expressed in terms of subset points and subset average class sizes is

$$P = \frac{\left(AP_1 \times \frac{60}{r_1} \times \bar{N}_1\right) + \ldots + \left(AP_n \times \frac{60}{r_n} \times \bar{N}_n\right)}{AP_1 + AP_2 + \ldots + AP_n} \ .$$

The ratios r_1, r_2, ..., r_n are constants and cannot be gamed.

It is assumed that subset credits cannot be gamed, i.e., that the distribution of credits is fixed. At the campus level, the distribution of students credits to the departments is determined by enrollment projections. At the department level, it is recognized that the distribution of credits is determined by historical pattern. It is assumed that, given the total number of department credits, department managers can, with a certain degree of accuracy, project the enrollments in homogeneous groups.

As shown in the next section, the parent-set productivity target of a campus can be achieved by gaming subset points or subset productivities. At the department level, the parent-set productivity target can be achieved by gaming subset points, subset productivities, or subset average class sizes.

The equation

$$P_i = \frac{60 \times SC_i}{AP_i}$$

effectively expresses subset productivity in terms of subset points alone, since SC_i is assumed to be fixed. Therefore, gaming subset points has the effect of gaming subset productivities. As AP_i increases, P_i decreases; as AP_i decreases, P_i increases. Similarly, the equation

$$P_i = \frac{60}{r_i} \times \bar{N}_i$$

effectively expresses subset productivity in terms of subset average class size alone, since, for each i, r_i is fixed. Therefore, gaming subset average class sizes has the effect of gaming subset productivities. As $\bar{N}_i$ increases, P_i increases; as $\bar{N}_i$ decreases, P_i decreases. Thus, the fundamental question, "What <u>can</u> $P_1, P_2, \ldots, P_n$ be in order to achieve P?" is equivalent to each of the following:

1. "What <u>can</u> $AP_1, AP_2, \ldots, AP_n$ be in order to achieve P?" and
2. "What <u>can</u> $\bar{N}_1, \bar{N}_2, \ldots, \bar{N}_n$ be in order to achieve P?"

<u>Gaming Subset Points</u>

In the equation

$$P = \frac{60 \times (SC_1 + SC_2 + \ldots + SC_n)}{AP_1 + AP_2 + \ldots + AP_n},$$

the subset credits $SC_1, SC_2, \ldots, SC_n$ are constant. The subset points AP_1, $AP_2, \ldots, AP_n$ are variable and are subject to gaming. The process of gaming subset points to achieve parent-set productivity is demonstrated in the following illustration.

<u>Illustration 4.1</u>. A level of aggregation S is partitioned into subsets S_1, S_2, and S_3. Student credits are projected as follows: 1000 credits into S_1, 1200 credits into S_2, and 1500 credits into S_3. The parent-set productivity target is 400. The following equation is obtained:

$$400 = \frac{60 \times (1000 + 1200 + 1500)}{AP_1 + AP_2 + AP_3}.$$

This simplifies to

$$400 \times (AP_1 + AP_2 + AP_3) = 60 \times 3700,$$

i. e., $AP_1 + AP_2 + AP_3 = 555$. Thus, a total of 555 points must be assigned. The distribution of the points depends, in part, on the pedagogical demands of the program. Suppose that the subset productivities of S_1, S_2, and S_3 should be kept relatively low, relatively high, and moderate, respectively, where 400 is considered a moderate productivity. For a preliminary assignment, the points may be distributed equally, i.e., let $AP_1 = AP_2 = AP_3 = 185$. Then the subset productivities are

$$P_1 = \frac{60 \times 1000}{185} = 324.3,$$

$$P_2 = \frac{60 \times 1200}{185} = 389.2,$$

and

$$P_3 = \frac{60 \times 1500}{185} = 486.5.$$

This distribution does not meet the pedagogical demands of the program: P_3 is too high and P_2 is too low. In order to <u>decrease</u> P_3, AP_3 must be <u>increased</u>. If points are to be added to S_3, an equal number of points must be <u>subtracted</u> from those assigned to S_1 and S_2, i.e., if P_3 is to be decreased, either P_1 or P_2 (or both) must be increased. But $P_1 = 324.3$ satisfies the pedagogical demands of S_1. It is decided to leave AP_1 at 185, i.e., the points to be added to S_3 are to be subtracted entirely from S_2. AP_3 is to be greater than 185 and AP_2 is to be correspondingly less than 185. A table can now be constructed. Table 5 provides subset productivities as AP_2 and AP_3 are changed by multiples of 10. In each distribution listed, $AP_1 = 185$ and $AP_1 + AP_2 + AP_3 = 555$ as required to achieve the parent-set productivity target of 400. Subset productivities are calculated from the equation

$$P_i = \frac{60 \times SC_i}{AP_i}.$$

Table 5
Illustration 4.1

$SC_1 = 1000$, $SC_2 = 1200$, $SC_3 = 1500$

$AP_1 + AP_2 + AP_3 = 555$

AP_1	AP_2	AP_3	P_1	P_2	P_3
185	185	185	324.3	389.2	486.5
185	175	195	324.3	411.4	461.5
185	165	205	324.3	436.4	439.0
185	155	215	324.3	464.5	418.6
185	145	225	324.3	496.6	400.0
185	135	235	324.3	533.3	383.0

The solution $AP_1 = 185$, $AP_2 = 145$, $AP_3 = 225$ seems to satisfy the pedagogical demands of the program, i.e., $P_1 = 324.3$ is relatively low, $P_2 = 496.6$ is relatively high, and $P_3 = 400.0$ is moderate. The parent-set productivity is achieved by virtue of $AP_1 + AP_2 + AP_3 = 555$.

Gaming Subset Productivities

Without the assistance of a specifically-designed computer program, subset productivities are extremely difficult to game. Theoretically, subset productivities can be gamed by the equation given in Theorem 4.4, i.e.,

$$P = \frac{SC}{\left(\frac{SC_1}{P_1}\right) + \left(\frac{SC_2}{P_2}\right) + \dots + \left(\frac{SC_n}{P_n}\right)}.$$

P is the parent-set productivity target and is constant. The subset credits SC_1, SC_2, ..., SC_n and the total credits SC are constant. The subset productivities P_1, P_2, ..., P_n are variable and are subject to gaming. The following illustration demonstrates how difficult this process can be if done by hand.

Illustration 4.2. A level of aggregation is partitioned into subsets S_1, S_2, and S_3. Student credits are projected as follows: 600 credits into S_1, 500 credits into S_2, and 300 credits into S_3. The parent-set productivity target is 400. The following equation is obtained:

$$400 = \frac{600 + 500 + 300}{\left(\frac{600}{P_1}\right) + \left(\frac{500}{P_2}\right) + \left(\frac{300}{P_3}\right)} .$$

Simplifying,

$$400 = \frac{1400}{\left(\frac{600}{P_1}\right) + \left(\frac{500}{P_2}\right) + \left(\frac{300}{P_3}\right)} ,$$

i.e.,

$$400 \times \left(\frac{600}{P_1} + \frac{500}{P_2} + \frac{300}{P_3}\right) = 1400.$$

Dividing both sides by 400,

$$\frac{600}{P_1} + \frac{500}{P_2} + \frac{300}{P_3} = 3.5.$$

Suppose the demands of the program are that P_1 be high, P_2 be moderate, and P_3 be low. One way to achieve the parent-set productivity target is to let $P_1 = P_2 = P_3 = 400$. Although these assignments do not satisfy the program demands, they may serve as preliminary assignments. In that case,

$$\begin{aligned} \frac{600}{P_1} + \frac{500}{P_2} + \frac{300}{P_3} &= \frac{600}{400} + \frac{500}{400} + \frac{300}{400} \\ &= 1.5 + 1.25 + .75 \\ &= 3.5, \end{aligned}$$

as expected. In order to satisfy the demands of the program, P_1 must be increased and P_3 must be decreased; but not, unfortunately, by equal amounts. For example, if $P_1 = 500$, $P_2 = 400$, and $P_3 = 300$, then

$$\frac{600}{P_1} + \frac{500}{P_2} + \frac{400}{P_3} = \frac{600}{500} + \frac{500}{400} + \frac{300}{300}$$

$$= 1.20 + 1.25 + 1.33$$

$$= 3.78,$$

not 3.5 as required. It is decided to let P_2 remain at 400. Then

$$\frac{600}{P_1} + \frac{500}{400} + \frac{300}{P_3} = 3.5,$$

i.e.,

$$\frac{600}{P_1} + 1.25 + \frac{300}{P_3} = 3.5,$$

i.e.,

$$\frac{600}{P_1} + \frac{300}{P_3} = 2.25,$$

i.e.,

$$\frac{600}{P_1} = 2.25 - \frac{300}{P_3},$$

i.e.,

$$\frac{600}{P_1} = \frac{(2.25 \times P_3) - 300}{P_3},$$

i.e.,

$$\frac{1}{P_1} = \frac{(2.25 \times P_3) - 300}{600 \times P_3},$$

i.e.,

$$P_1 = \frac{600 \times P_3}{(2.25 \times P_3) - 300}.$$

Gaming can now occur by assigning arbitrary values to P_3 and using the above equation to compute P_1. For example, if $P_3 = 390$ (P_3 is to be decreased from 400), then

$$P_1 = \frac{600 \times 390}{(2.25 \times 390) - 300}$$

$$= \frac{234,000}{877.5 - 300}$$

$$= \frac{234,000}{577.5}$$

$$= 405.2.$$

Table 6 lists subset productivities as P_3 decreases from 400 by multiples of 10.

Table 6
Illustration 4.2

$SC_1 = 600$, $SC_2 = 500$, $SC_3 = 300$

$$\frac{600}{P_1} + \frac{500}{P_2} + \frac{300}{P_3} = 3.5$$

P_1	P_2	P_3
400	400	400
405.2	400	390
410.8	400	380
416.9	400	370
423.5	400	360
430.8	400	350
438.7	400	340
447.5	400	330
457.1	400	320
467.9	400	310
480	400	300

It is decided to assign subset productivity targets as follows: $P_1 = 450$, $P_2 = 400$, and $P_3 = 330$. These will yield a parent-set productivity of slightly more than the targeted 400.

Gaming Subset Average Class Sizes

Gaming subset average class sizes is at least as difficult as gaming subset productivities. Moreover, it can only be done at the department level. Suppose a department D is partitioned into groups $G_0, G_1, \ldots, G_n$, where G_0 is the non-teaching component and $G_1, \ldots, G_n$ are homogeneous groups. If a parent-set productivity target P is given, then the parent-set instructional productivity P* is given by

$$P^* = \frac{AP}{TP} \times P,$$

where AP is the total number of points assigned and TP is the total number of teaching points assigned. Thus, achievement of P through G_0, G_1, ..., G_n is equivalent to achievement of P^* through G_1, ..., G_n. Let r_i be the point-to-credit ratio and $\bar{N}_i$ the average class size of the group G_i. Then the subset productivity P_i is given by

$$P_i = \frac{60}{r_i} \times \bar{N}_i.$$

Therefore, by Theorem 4.4,

$$P^* = \frac{SC}{\left[\frac{SC_1}{\left(\frac{60}{r_1}\right) \times \bar{N}_1}\right] + \ldots + \left[\frac{SC_n}{\left(\frac{60}{r_n}\right) \times \bar{N}_n}\right]},$$

i.e.,

$$P^* = \frac{60 \times (SC_1 + \ldots + SC_n)}{\left(\frac{r_1 \times SC_1}{\bar{N}_1}\right) + \ldots + \left(\frac{r_n \times SC_n}{\bar{N}_n}\right)}.$$

The quantities SC, SC_1, ..., SC_n, r_1, ..., r_n are constants. P^* is a target and is thus a constant. The quantities $\bar{N}_1$, ..., $\bar{N}_n$ are variables, and are subject to gaming. If $n > 2$, gaming $\bar{N}_1$, ..., $\bar{N}_n$ can be extremely difficult if done by hand. No illustration will be given.

<u>Summary</u>

Let S be a given level of aggregation and let S_1, S_2, ..., S_n form a partition of S into pairwise disjoint, exhaustive subsets. Then a given productivity target, P, of S can be achieved by gaming various subset phenomena. Since subset student credits, SC_1, SC_2, ..., SC_n, are

determined by enrollment projection, they are constant and thus are not subject to gaming.

The subset assigned points, AP_1, AP_2, ..., AP_n, can be gamed by virtue of the equation

$$P = \frac{60 \times (SC_1 + SC_2 + \ldots + SC_n)}{AP_1 + AP_2 + \ldots + AP_n} .$$

The subset productivities, P_1, P_2, ..., P_n, can be gamed by virtue of the equation

$$P = \frac{SC_1 + SC_2 + \ldots + SC_n}{\left(\frac{SC_1}{P_1}\right) + \left(\frac{SC_2}{P_2}\right) + \ldots + \left(\frac{SC_n}{P_n}\right)} .$$

At the department level, where the subsets are homogeneous groups of courses, an instructional productivity target, P*, can be achieved by gaming average class sizes, $\overline{N}_1$, $\overline{N}_2$, ..., $\overline{N}_n$. The applicable equation is

$$P^* = \frac{60 \times (SC_1 + \ldots + SC_n)}{\left(\frac{r_1 \times SC_1}{\overline{N}_1}\right) + \ldots + \left(\frac{r_n \times SC_n}{\overline{N}_n}\right)} ,$$

where r_1, r_2, ..., r_n are the point-to-credit ratios of the homogeneous groups S_1, S_2, ..., S_n, respectively.

Of all the choices of subset phenonema to game, the most convenient is assigned points. Moreover, gaming subset points is, in effect, equivalent to gaming both subset productivities and subset average class sizes, since, for each i,

$$P_i = \frac{60 \times SC_i}{AP_i} ,$$

where SC_i is constant, and

$$\overline{N}_i = \frac{r_i \times SC_i}{AP_i} ,$$

where both SC_i and r_i are constant. Two point-gaming techniques that can be utilized to achieve productivity targets at the department and campus levels are presented in the next sections.

Managing Department Productivity

An illustration of how department chairpersons can control, i.e., manage, department productivity by gaming subset points is given in the scenario presented below.

Scenario 4.1. Suppose, for a given term, a department has a productivity target of 450 and a projected 9000 student credits. Then, in order to achieve the target, the number of points to be assigned must be

$$AP = \frac{60 \times 9000}{450} = 1200.$$

Of these 1200 points, suppose 52 are to be released points. Then the total number of teaching points that must be assigned is TP = 1200 - 52 = 1148, and the department must achieve an instructional productivity of

$$P^* = \frac{1200}{1148} \times 450 = 470.4.$$

Suppose there are three homogeneous groups: G_1 consists of all 3-credit classes to each of which 12 points are assigned, G_2 consists of all 5-credit classes to each of which 20 points are assigned, and G_3 consists of all one-credit labs to each of which 6 points are assigned. Then point-to-credit ratios are $r_1 = 12/3 = 4$, $r_2 = 20/5 = 4$, and $r_3 = 6/1 = 6$, respectively. Suppose that, using historical patterns, the chairperson projects that the 9000 credits will be distributed as follows:

$$G_1 : SC_1 = 6000$$

$$G_2 : SC_2 = 2000$$

$$G_3 : SC_3 = 1000$$

To each group, the chairperson may assign a <u>trial</u> average class size. Suppose he/she does so as follows:

$$G_1 : \overline{N}_1 = 32$$

$$G_2 : \overline{N}_2 = 28$$

$$G_3 : \overline{N}_3 = 20$$

The chairperson may now compute trial productivities:

$$G_1 : P_1 = \frac{60}{4} \times 32 = 15 \times 32 = 480$$

$$G_2 : P_2 = \frac{60}{4} \times 28 = 15 \times 28 = 420$$

$$G_3 : P_3 = \frac{60}{6} \times 20 = 10 \times 20 = 200$$

The chairperson may now compute, to the nearest integer, the number of points necessary to assign to each group, assuming the trial productivities. These are as follows:

$$G_1 : AP_1 = \frac{60 \times SC_1}{P_1} = \frac{60 \times 6000}{480} = 750$$

$$G_2 : AP_2 = \frac{60 \times SC_2}{P_2} = \frac{60 \times 2000}{420} = 286$$

$$G_3 : AP_3 = \frac{60 \times SC_3}{P_3} = \frac{60 \times 1000}{200} = 300$$

The chairperson may now sum the subset points:

$$AP_1 + AP_2 + AP_3 = 1336.$$

This sum exceeds the number of teaching points that <u>must</u> be assigned, 1148, by 188. The chairperson must now subtract a total of 188 from the trial

numbers of points. Suppose, for pedagogical reasons, the chairperson subtracts 140 points from the trial value of AP_1, 48 points from the trial value of AP_2, and zero points from the trial value of AP_3. Then the numbers of points to be assigned to the groups are now as follows:

$$G_1 : AP_1 = 750 - 140 = 610$$

$$G_2 : AP_2 = 286 - 48 = 238$$

$$G_3 : AP_3 = 300 - 0 = 300$$

Now $AP_1 + AP_2 + AP_3 = 1148$ as required. Since all the classes in G_1 are worth 12 points, points in G_1 must be assigned in multiples of 12. By long division,

$$\frac{610}{12} = 50 + \frac{10}{12},$$

i.e.,

$$610 = (12 \times 50) + 10.$$

The remainder, 10, may be dropped. Thus, the number of points <u>actually</u> to be assigned in G_1 is $AP_1 = 12 \times 50 = 600$ and, moreover, 50 classes will be scheduled. Similarly, since all the classes in G_2 are worth 20 points, points in G_2 must be assigned in multiples of 20. By long division,

$$\frac{238}{20} = 11 + \frac{18}{20},$$

i.e.,

$$238 = (20 \times 11) + 18.$$

The remainder, 18, is dropped. Thus, the number of points <u>actually</u> to be assigned in G_2 is $AP_2 = 20 \times 11 = 220$ and, moreover, 11 classes will be scheduled. Points in G_3 must be assigned in multiples of 6. But 300 is a multiple of 6 since $300 = 6 \times 50$. Thus, the number of points <u>actually</u> to be assigned in G_3 is $AP_3 = 6 \times 50 = 300$ and, moreover, 50 of these labs will

be offered. A summary of the results is presented in Table 7. Subset productivities are obtained from the equation

$$P_i = \frac{60 \times SC_i}{60} ,$$

and average class sizes are obtained from the equation

$$\bar{N}_i = \frac{r_i \times P_i}{60} .$$

Table 7
Scenario 4.1

Group	Credits	Points	Number of Sections	Productivity	Average Class Size
G_1	6000	600	50	600	40
G_2	2000	220	11	545.5	36.4
G_3	1000	300	50	200	20

For the department, the number of student credits is 9000 and the number of teaching points is 600 + 220 + 300 = 1120. Thus the total number of points assigned is 1120 + 52 = 1172. The department's productivity is

$$P = \frac{60 \times 9000}{1172} = 460.8,$$

which is comfortably over the 450 target. The 10.8 excess is a cushion that resulted from dropping the remainders when the numbers of sections were computed by long division. If the chairperson determines that these results do not satisfy the pedagogical demands of the program, then he/she must return to the step where points were subtracted from those obtained from the trial productivities and repeat the subsequent steps.

Managing Campus Productivity

Management of productivity at the campus level may require a computer program specifically designed for that purpose because of the large number

of subsets, i.e., departments, involved. An alternative would be to impose intermediate groupings. For example, three or four departments may be grouped into "divisions" and three or four divisions may constitute the campus. Campus productivity may then be controlled by gaming division points, division productivity may be controlled by gaming department points, and department productivity may be controlled by gaming points assigned to homogeneous groups. If more than 20 departments exist and a point-gaming computer program is not available, then a second intermediate grouping may have to be imposed. The logic of the gaming process that can be used to control campus productivity is illustrated in the following scenario.

Scenario 4.2. Suppose a campus contains four departments D_1, D_2, D_3, and D_4 and the campus productivity target is 400. Suppose, for a given term, 50,000 student credits are projected to be distributed as follows:

$$D_1 : SC_1 = 20,000$$

$$D_2 : SC_2 = 15,000$$

$$D_3 : SC_3 = 10,000$$

$$D_4 : SC_4 = 5,000$$

Then, in order to achieve the target, the number of points to be assigned campuswide is

$$AP = \frac{60 \times 50,000}{400} = 7,500.$$

Suppose that, due to differing pedagogical demands of the departments, uniform productivity assignments of 400 cannot be made and that the campus dean, who is aware of these demands, assigns trial productivities as follows:

$$D_1 : P_1 = 450$$
$$D_2 : P_2 = 410$$
$$D_3 : P_3 = 380$$
$$D_4 : P_4 = 350$$

The dean may now compute, to the nearest integer, the number of points necessary to be assigned in each department, assuming the trial productivities. They are:

$$D_1 : AP_1 = \frac{60 \text{ x } 20{,}000}{450} = 2{,}667$$
$$D_2 : AP_2 = \frac{60 \text{ x } 15{,}000}{410} = 2{,}195$$
$$D_3 : AP_3 = \frac{60 \text{ x } 10{,}000}{380} = 1{,}579$$
$$D_4 : AP_4 = \frac{60 \text{ x } 5{,}000}{350} = 857$$

The dean may now sum the results:

$$AP_1 + AP_2 + AP_3 + AP_4 = 7{,}298.$$

The sum is 202 points less than the required 7,500. The dean thus must add a total of 202 points to the preliminary totals. The effect of adding points is reduced productivity. Suppose the dean decides to add 100 points to the trial value of AP_1, 40 points to the trial value of AP_2, 40 points to the trial value AP_3, and 22 points to the trial value of AP_4. Then the numbers of points to be assigned are as follows:

$$D_1 : AP_1 = 2{,}667 + 100 = 2{,}767$$
$$D_2 : AP_2 = 2{,}195 + 40 = 2{,}235$$
$$D_3 : AP_3 = 1{,}579 + 40 = 1{,}619$$
$$D_4 : AP_4 = 857 + 22 = 879$$

The dean may now compute subset productivity targets:

$$D_1 : P_1 = \frac{60 \times 20,000}{2,767} = 433.7$$

$$D_2 : P_2 = \frac{60 \times 15,000}{2,235} = 402.7$$

$$D_3 : P_3 = \frac{60 \times 10,000}{1,619} = 370.6$$

$$D_4 : P_4 = \frac{60 \times 5,000}{875} = 341.2$$

By rounding each of these up to the next integer (or higher), the dean would provide the campus with a cushion. A summary of the results is presented in Table 8.

Table 8
Scenario 4.2

Department	Credits	Productivity Target
D_1	20,000	434
D_2	15,000	403
D_3	10,000	371
D_4	5,000	342

If the department productivity targets are achieved, then the campus productivity would be

$$P = \frac{50,000}{\left(\frac{20,000}{434}\right) + \left(\frac{15,000}{403}\right) + \left(\frac{10,000}{371}\right) + \left(\frac{5,000}{342}\right)} = 400.4,$$

which slightly exceeds the 400 target.

Once the campus dean computes the department productivity targets, he/she may report to each department chairperson the projected number of credits and the productivity target for the department. Each chairperson may then game as in Scenario 4.1.

Other Control Mechanisms

The productivity model, combined with the concepts of subset productivity and gaming to achieve a productivity target is, by itself, an

effective feedforward control system that assures financial stability provided (a) the enrollment projection is correct and (b) enrollment is either stable or increasing. If an enrollment projection is incorrect in that it either overprojects total campus credits and/or projects the distribution of credits to departments incorrectly, or if enrollment is declining regardless of projection accuracy, then the productivity model alone does not assure financial stability. Other safety mechanisms may have to be incorporated into the campus' policies and procedures to protect the campus from the occurrence of any of these phenomena.

Productivity is the ratio of student credits to FTEF. If a department employs a certain number of full-time faculty members, each one of them must be assigned a full load every term. Thus, in the productivity formula, the possible values for FTEF have a lower bound which, during a standard term, is the number of full-time faculty employed. For example, suppose a department employing 12 full-time faculty members has a productivity target of 450. Then FTEF has a minimum value of 12 and, in order to achieve its target, the department must generate at least 12 x 450 = 5,400 credits. If fewer than 5,400 credits are produced, then the department cannot achieve its target. The department is overstaffed.

There are alternate solutions to the overstaffing problem. Overstaffing can occasionally be prevented through normal faculty attrition, i.e., retirements and resignations. It is sometimes feasible to transfer faculty from overstaffed departments to understaffed departments, e.g., from Physics to Mathematics. The feasibility of this solution depends on faculty members' qualifications and desires.

Another solution to the problem of overstaffing is feedforward in nature. It is to maintain a policy that departments purposely be

understaffed. Staffing requirements may then be based on a given percentage of projected need. For example, suppose a given department is to be staffed at 80 percent of projected need. Suppose its productivity target is 450 and its projected number of student credits for a given term is 7,000. Then its projected need, in terms of FTEF, is

$$\text{FTEF} = \frac{7{,}000}{450} = 15.5.$$

The number of full-time faculty members that the department can employ is 80 percent of 15.5, i.e., 12. The remaining 3.5 FTEF would consist of part-time (adjunct) faculty and full-time faculty overload. The 3.5 FTEF provide a cushion in case the credits are overprojected. The specified percentage of anticipated need at which departments are to be staffed may vary from department to department depending on the availability of qualified part-time faculty.

Another type of problem may occur when there is a sudden, significant shifting of enrollment to departments that maintain low productivity. The effect of increasing proportions of enrollment in low-productivity areas is lower campus productivity. When this phenomenon occurs, department targets may be regamed as in Scenario 4.2.

If, prior to the beginning of a given term, it appears that one or more departments will not achieve their productivity targets, one option for the campus dean is to cancel low-enrollment classes from the schedule. Cancelling classes in a department alters its productivity--both credits and points are removed. The effect of cancelling a low-enrollment, i.e., low-productivity, class is to raise department productivity. One way to minimize the necessity of cancelling classes is to begin the registration period with a class schedule that contains fewer classes than presumably

needed. As these fill, additional classes can be added to the schedule one at a time.

There are various mechanisms that can be incorporated into a campus' policies and procedures to protect the campus from enrollment fluctuations. These mechanisms, combined with a productivity model equipped with the gaming techniques to control productivity, provide the campus with an effective feedforward control system that can potentially assure financial stability and allows for the maintenance of a high quality educational program.

Summary

The purpose of this chapter was to demonstrate how the productivity model,

$$P = \frac{60 \times SC}{AP},$$

can be used to manage the productivities of instructional programs in a community college. At the campus level, productivity can be managed by combining the model with enrollment projections, parent-set (campus) and subset (department) productivity targets, and various gaming techniques. At the department level, productivity can be managed by combining the model with enrollment projections, parent-set (department) and subset (homogeneous-group) productivity targets, and gaming.

The functions of an enrollment projection are (a) to predict the total number of student credits that a parent-set will produce during a future academic term and (b) to predict how these credits will be distributed among the various subsets. The effectiveness of the productivity model in managing productivity depends on the accuracy of enrollment projections.

At the campus level, the productivity target must be high enough to insure financial stability. At the department levels, productivity targets must be high enough to insure that the campus target is achieved, yet low enough to provide for effective instruction.

Applications of the productivity model to manage productivity at any level of aggregation depend on the relationships between parent-set and subset phenomena. These relationships are given as theorems in this study. These theorems are summarized below.

Let S be a given level of aggregation and let $S_1, S_2, \ldots, S_n$ form a partition of S. Let P be the productivity of S. For each $i = 1, 2, \ldots, n$, let

(a) P_i be the productivity of S_i,

(b) SC_i be the number of student credits produced by S_i, and

(c) AP_i be the number of points assigned in S_i.

Then:

(a) $$P = \frac{60 \times (SC_1 + SC_2 + \ldots + SC_n)}{AP_1 + AP_2 + \ldots + AP_n} \quad \text{(Theorem 4.1)},$$

(b) $$P = \frac{(AP_1 \times P_1) + (AP_2 \times P_2) + \ldots + (AP_n \times P_n)}{AP_1 + AP_2 + \ldots + AP_n} \quad \text{(Theorem 4.2)},$$

and

(c) $$P = \frac{SC_1 + SC_2 + \ldots + SC_n}{\left(\frac{SC_1}{P_1}\right) + \left(\frac{SC_2}{P_2}\right) + \ldots + \left(\frac{SC_n}{P_n}\right)} \quad \text{(Theorem 4.4)}.$$

Parent-set productivity can be managed by gaming subset phenomena. Since subset student credits, $SC_1, SC_2, \ldots, SC_n$, are determined by enrollment projections, they are constant and cannot be gamed. Theorem 4.1 can be used by academic administrators to achieve a given parent-set

productivity target P by gaming the subset assigned points, AP_1, AP_2, ... , AP_n. Theorem 4.4 can be used by academic administrators to achieve a given parent-set productivity target P by gaming the subset productivities, P_1, P_2, ... , P_n.

At the department level, productivity P and instructional productivity P* are related by the equations

$$P = \frac{TP}{AP} \times P^* \text{ and } P^* = \frac{AP}{TP} \times P \quad \text{(Theorem 4.3)},$$

where AP represents the number of assigned points and TP represents the number of teaching points, i.e., assigned points minus released points. Thus, a given departmental productivity target P determines a proportionally higher instructional productivity target P*. The productivity P_i of a homogeneous group of courses is related to average class size, $\overline{N}_i$, by the equation

$$P_i = \frac{60}{r_i} \times \overline{N}_i \quad \text{(Theorem 3.4)},$$

where r_i is the common point-to-credit ratio. Thus, the equation of Theorem 4.4 can be written in the form

$$P^* = \frac{60 \times (SC_1 + \ldots + SC_n)}{\left(\frac{r_1 \times SC_1}{\overline{N}_1}\right) + \ldots + \left(\frac{r_n \times SC_n}{\overline{N}_n}\right)},$$

and this equation can be used to achieve a given departmental instructional productivity target P* by gaming the subset (homogeneous-group) average class sizes, $\overline{N}_1$, $\overline{N}_2$, ... , $\overline{N}_n$.

Of all the choices of subset phenomena to game (assigned points, productivities, and average class sizes), the most convenient is assigned

points. At the departmental level, a technique for achieving a given instructional productivity target contains two basic steps. They are (a) assign trial subset (homogeneous-group) average class sizes and (b) game the subset points. At the campus level, a technique for achieving a given productivity target also contains two basic steps. They are (a) assign trial subset (departmental) productivities and (b) game the subset points.

The productivity model, combined with enrollment projections, productivity targets, and gaming, cannot, by itself, insure financial stability. Its reliability depends greatly on the accuracy of enrollment projections. Other provisions, such as deliberate understaffing of departments and careful term-by-term monitoring of low-enrollment classes, may have to be utilized in order to protect the community college from declining or shifting enrollment.

CHAPTER V

SUMMARY AND RECOMMENDATIONS FOR FURTHER STUDY

The Need for this Study

In order to achieve a steady state, community colleges are required to adapt to a wide variety of changing conditions. It is highly desirable that community colleges maintain control systems that can accommodate demands for change. In particular, the existence of control systems that can measure the economic consequences of decisions pertaining to current and future instructional programs is essential to maintain a state of financial stability. Any such system should be able to measure consequential income against consequential cost. The academic accounting model presented in this study is such a system.

On the average, approximately two-thirds of a community college's income derives from the state. In most cases, state income is enrollment-dependent. Another major source of income, student tuition and fees, is also enrollment-dependent. Other sources of income tend to be fixed and independent of enrollment. Thus, enrollment tends to be a reliable indicator of a community college's variable income. The methods used by the states to measure enrollment are diverse. Most states measure enrollment in terms of FTE or something equivalent. But, in turn, one FTE is an aggregation of some other unit such as the student credit, the student contact hour, headcount, or a mixture thereof.

The major component of instructional cost is faculty salaries. Thus, the number of full faculty workload units, FTEF, tends to be a reliable indicator of a community college's cost. At the same time, it must be recognized that workload equity is a desirable goal and that there exists a

wide variety of possible faculty activities, including teaching and non-teaching activities, that should contribute to workload. It is, therefore, necessary to develop categories of recognized faculty activities. By assigning "points" to faculty members engaged in such activities, it is then possible to quantity FTEF in terms of points assigned.

Once enrollment is quantified in terms of funding units that generate state income and FTEF is quantified in terms of points assigned for recognized faculty activities, it is possible to derive a mathematical productivity model. A productivity model is one that expresses productivity as a ratio: the number of funding units produced per FTEF. Concomitantly, productivity is a measure of cost-effectiveness, the ratio of income to cost.

The Review of the Literature

The review of the literature was divided into three parts. First, since Control Theory provided the theoretical base for the study, a review of literature pertaining to managerial control was conducted. This literature identified the components common to all control systems; enumerated the principles of control; and provided evidence that controlling is as integral an aspect of management as planning, organizing, directing, and communicating. Moreover, the literature demonstrated that the ideal control system is a feedforward system that is capable of adjusting either inputs or designed activities before activities occur in order to achieve desired results.

The second review conducted was of state funding practices. Human capital studies indicate that support of postsecondary education is a sound investment and that the major burden of such support should ideally be assumed by the public. Public support of postsecondary education,

accomplished by the provision of state funds, has, in fact, increased. The methods of support, however, are diverse. Educational finance scholars suggest that funding formulas, based on readily available units that correspond to measures of student load, are the most objective means for allocating funds.

The third aspect of the literature review pertained to faculty workload. Various time-analysis studies demonstrated that faculty members spend a significant portion of their time engaged in activities that occur outside the formal classroom. The consensus of faculty workload scholars was that many of these activities should be folded into workload assignments and that workload assignments should be made equitably. Several community colleges utilize various faculty assignment systems that recognize both teaching and non-teaching activities in their efforts to achieve workload equity. The point system at Miami-Dade Community College is such a system. This point system provided the basis for developing the faculty workload component of the academic accounting model presented in this study.

Development of the Model

The academic accounting model presented in Chapter III was developed in three steps. First, data pertaining to various state funding systems were collected by means of telephone interviews of officials or staff members of the state agencies responsible for community college affairs in 42 states. The primary purpose of each interview was to determine whether or not enrollment is a factor in the distribution of state funds to community colleges and, if so, to identify the specific units that serve to measure enrollment. The data were presented in a state-by-state summary and were then condensed into a table. It was found that 34 of the 42 states surveyed utilize enrollment as a factor in the allocation of state funds to community

colleges and that the predominant unit used to measure enrollment is the student credit.

Second, the faculty workload model was presented. The concept of FTEF was quantified by means of a point system and points were assigned in various categories of faculty activity. These categories were defined on the basis of studies presented in the faculty workload portion of the literature review and included presentation, supervision, compensation, management, planning and development, sponsorship, service/research, and paraprofessional. One FTEF was equated to 60 points and, at any level of aggregation, the total number of FTEF was defined to be the total number of assigned points (AP) divided by 60, i.e.,

$$FTEF = \frac{AP}{60} .$$

Assigned points comprised both teaching points (TP) and released points (RP).

The third step in the development of the academic accounting model was the presentation and investigation of the productivity model. The productivity model was expressed as an equation

$$P = \frac{SC}{FTEF} ,$$

or, equivalently,

$$P = \frac{60 \times SC}{AP} ,$$

where P is productivity and SC is the number of student credits produced.

The elementary properties of the productivity model were derived in Chapter III through a series of theorems. Specifically, the theorems demonstrated the relationships that exist between productivity and class size. These relationships are summarized in Appendix B. The theorems also provided shortcut methods for computing productivity and the means by which

productivity can be computed from quantities different from those given in the original model. Wherever appropriate, examples were presented to illustrate the properties given by the theorems.

Application of the Model

The purpose of Chapter IV was to demonstrate how the academic accounting model can be utilized as a feedforward control system. This was referred to as "management of productivity" or "control of productivity."

At the level of aggregation of a single class or a group of "homogeneous" classes, productivity can be controlled by the utilization of enrollment projections, productivity targets, and alternate forms of productivity equations presented in Chapter III. At higher levels of aggregation, such as the department level and the campus level, productivity can be controlled by the utilization of enrollment projections, productivity targets, subset productivity, and gaming.

Computerized enrollment projection models extrapolate historical data in order to predict the total number of student credits to be generated by a campus during a future academic term or year. Administrators and staff use historical data to predict how these credits are to be distributed among various departments.

In order for a campus to remain financially stable, a certain level of productivity must be achieved. It is therefore necessary to set a campus productivity target. But campus productivity results from the productivities achieved by academic departments. It is therefore necessary to set a productivity target for each department. Since the pedagogical demands that exist among the various departments are diverse, department productivity targets may be non-uniform.

Subsets are formed by partitioning a parent set. The standard subsets into which a campus is partitioned are the departments. The standard subsets into which a department is partitioned are homogeneous groups of courses together with that portion of the program to which only released points are assigned.

The relationships between parent-set productivity and various subset measures were given by a series of theorems and corollaries. The subset measures considered were subset credits, subset points, subset productivities, and subset average class sizes. Applications of the theorems and corollaries were presented in a series of problems and solutions.

Parent-set productivity can be controlled by means of gaming subset variables. Since enrollment projections determine subset credits, these are considered fixed and cannot be gamed. The only subset measures subject to gaming are points, productivities, and average class sizes. A series of illustrations demonstrated that the most convenient variables to game are subset points. Two scenarios illustrated point-gaming methods for achieving department and campus productivity targets.

Recommendations for Further Study

The following recommendations for topics of further study are presented.

1. Productivity models should be developed for community colleges that generate state income on the basis of funding units other than student credits. In particular, an SCH model and a mixed funding unit model, for community college that are required to measure enrollment differently in different programs, should be developed. It is suggested that applications of these models utilize enrollment projections, productivity targets, subset productivities, and point-gaming techniques as presented in this study.

2. Point-gaming computer programs should be designed to assist managers in controlling parent-set productivity at the department and campus levels. These programs should be designed for use on microcomputers.

3. A study should be made of various enrollment projection techniques currently used by community colleges. The study should include comparisons of predicted data and actual data so that the reliabilities of these projection techniques can be assessed. The management of productivity by means of the academic accounting model presented in this study depends heavily on the accuracy of enrollment projections.

4. A study should be made of the various policies and procedures used by community colleges to protect their financial stability against such phenomena as inaccurate enrollment projections, declining enrollment, or the shifting of enrollment into low productivity courses.

5. The academic accounting model presented in this study should be adapted to other settings such as four-year colleges and universities. In particular, the faculty workload model must be redesigned to accommodate the faculty workload requirements in these settings. The partitioning of a university's academic program may be more complex if the university comprises colleges and the colleges in turn comprise departments. But the gaming of subset variables to achieve parent-set productivity should be similar to that given in this study.

APPENDIX A

STATE OFFICERS/STAFF MEMBERS INTERVIEWED TO OBTAIN DATA ON STATE FUNDING SYSTEMS

Alabama. Chris Bond, Alabama State Department of Postsecondary Education, Montgomery, Alabama 36104.
Telephone: (205) 834-2200.

Arizona. Ann Ogden, State Board of Directors for Community Colleges of Arizona, Phoenix, Arizona 85009.
Telephone: (602) 255-4037.

Arkansas. JoAnne Branscum, Department of Higher Education, Little Rock, Arkansas 72201.
Telephone: (501) 371-1441.

California. Shirley Simmons, California Community Colleges, Sacramento, California 95814.
Telephone: (916) 322-4005.

Colorado. Dick Shubert, State Board for Community Colleges and Occupational Education, Denver, Colorado 80203.
Telephone: (303) 866-3162.

Connecticut. Andrew McKirdy, Regional Community Colleges, Hartford, Connecticut 06105.
Telephone: (203) 566-8760.

Delaware. Raymond Doffs, Delaware Technical and Community Colleges, Dover, Delaware 19901.
Telephone: (302) 736-4621.

Florida. Jack Ebberley, Division of Community Colleges, Tallahassee, Florida 32301.
Telephone: (904) 488-7926.

Georgia. Haskin Pounds, University System of Georgia, Atlanta, Georgia 30334.
Telephone: (404) 656-2213.

Illinois. Bill Matlack, Illinois Community College Board, Springfield, Illinois 62704.
Telephone: (217) 786-6000.

Iowa. Bob Yaeger, Area Schools and Career Education Branch, Des Moines, Iowa 50319.
Telephone: (515) 281-3124.

Kansas. Dale Dennis, State Department of Education, Topeka, Kansas 66611.
Telephone: (913) 296-3047.

Kentucky. Jack Jordan, University of Kentucky, Lexington, Kentucky 40506.
Telephone: (606) 257-4751.

Louisiana. John Kehoe, Department of Education, Baton Rouge, Louisiana 70814.
Telephone: (504) 342-6950.

Maryland. Joseph Buruss, State Board for Community Colleges, Annapolis, Maryland 21401.
Telephone: (301) 269-2881.

Massachusetts. Trish Kruza, Board of Regents of Higher Education, Boston, Massachusetts 02108.
Telephone: (617) 727-0693.

Michigan. Robert Endriss, Community College Service Unit, Lansing, Michigan 48090.
Telephone: (517) 373-0870.

Minnesota. Don Voychek, Minnesota Community College System, St. Paul, Minnesota 55101.
Telephone: (612) 296-7426.

Mississippi. George Moody, Division of Junior Colleges, Jackson, Mississippi 39205.
Telephone: (601) 359-3520.

Missouri. Jean Vickery, Department of Higher Education, Jefferson City, Missouri 65101.
Telephone: (314) 751-2361.

Montana. Steve Bennyhoff, Office of the Coordinator of Community Colleges, Helena, Montana 59620.
Telephone: (406) 449-3024.

Nebraska. Sue Geffner, Coordinating Commission for Postsecondary Education, Lincoln, Nebraska 68509.
Telephone: (402) 471-2847.

Nevada. Ron Sparks, University of Nevada System, Reno, Nevada 89509.
Telephone: (702) 784-4901.

New Hampshire. Marie Mills, State Department of Education, Concord, New Hampshire 03301.
Telephone: (603) 271-2727.

New Jersey. Jane Rose, Office of Community College Programs, Trenton, New Jersey 08625.
Telephone: (609) 292-4470.

<u>New Mexico</u>. Mark Valdez, Board of Educational Finance, Santa Fe, New Mexico 87503.
Telephone: (505) 827-8300.

<u>New York</u>. David Van Nortwick, Office of the Chancellor for Community Colleges, Albany, New York 12246.
Telephone: (518) 473-1843.

<u>North Carolina</u>. Larry Morgan, State Department of Community Colleges, Raleigh, North Carolina 27611.
Telephone: (919) 733-6505.

<u>North Dakota</u>. Floyd Case, State Board of Higher Education, Bismarck, North Dakota 58505.
Telephone: (701) 224-2960.

<u>Ohio</u>. Rosemary Jones, Ohio Board of Regents, Columbus, Ohio 43215.
Telephone: (614) 466-5045.

<u>Oklahoma</u>. Edward Coyle, State System of Higher Education, Oklahoma City, Oklahoma 73105.
Telephone: (405) 521-2444.

<u>Oregon</u>. Jewel Manspeaker, Oregon State Department of Education, Salem, Oregon 97310.
Telephone: (503) 378-8639.

<u>Pennsylvania</u>. Jim Hobbs, Division of Postsecondary Education, Harrisburg, Pennsylvania 17108.
Telephone: (717) 783-6779.

<u>South Carolina</u>. Don Peterson, State Board for Technical and Comprehensive Education, Columbia, South Carolina 29210.
Telephone: (803) 758-6965.

<u>Tennessee</u>. Clay Harkleroad, Community College Division, Nashville, Tennessee 37217.
Telephone: (615) 741-4821.

<u>Texas</u>. Jim Nance, Texas College and University System, Austin, Texas 78711.
Telephone: (512) 475-2138.

<u>Utah</u>. Donald Carpenter, Utah State Board of Regents, Salt Lake City, Utah 84102.
Telephone: (801) 533-5617.

<u>Virginia</u>. Brook Aker, Virginia Community College System, Richmond, Virginia 23212.
Telephone: (804) 786-0000.

<u>Washington</u>. Bill Jacobs, State Board for Community College Education, Olympia, Washington 98504.
Telephone: (206) 753-3670.

<u>West Virginia</u>. Ed Grose, West Virginia Board of Regents, Charleston, West Virginia 25301.
Telephone: (304) 348-2101.

<u>Wisconsin</u>. Ron Braem, Board of Vocational, Technical, and Adult Education, Madison, Wisconsin 53702.
Telephone: (608) 266-1770.

<u>Wyoming</u>. Oliver Sundby, Community College Commission, Cheyenne, Wyoming 82002.
Telephone: (307) 377-7763.

APPENDIX B

DEFINITIONS OF SYMBOLS; SUMMARY OF RELATIONSHIPS

Symbols

a_i	The percentage of faculty workload points assigned to the subset S_i in a partition of a given level of aggregation S.
AP	The number of faculty workload points assigned in a given level of aggregation.
AP_i	The number of faculty workload points assigned to the subset S_i in a partition of a given level of aggregation S.
c_i	The percentage of student credits produced by the subset S_i in a partition of a given level of aggregation S.
FTEF	The number of full-time equivalent faculty in a given level of aggregation S.
N	Class size.
$\bar{N}$	Average class size in a homogeneous group of courses.
P	The productivity of a given level of aggregation S.
P_i	The productivity of the subset S_i in a partition of a given level of aggregation S.
P^*	Instructional productivity; the productivity of the portion of a given level of aggregation S that produces student credits.
r	The point-to-credit ratio of a class or a group of homogeneous courses.
RP	The number of released points assigned to a given level of aggregation S.
S	A given level of aggregation; the parent-set of a given partition.
S_i	A subset of a given parent-set S.
SC	The number of student credits produced by a given level of aggregation S.
SC_i	The number of student credits produced by the subset S_i in a partition of a given level of aggregation S.

TP The number of teaching points assigned to a given level of aggregation S.

Relationships

$$P = \frac{SC}{FTEF} \quad ; \quad FTEF = \frac{SC}{P}$$

$$FTEF = \frac{AP}{60}$$

$$P = \frac{60 \times SC}{AP} \quad ; \quad AP = \frac{60 \times SC}{P}$$

$$P = \frac{60}{r} \times N \quad ; \quad N = \frac{P \times r}{60}$$

$$P = \frac{60}{r} \times \overline{N} \quad ; \quad \overline{N} = \frac{P \times r}{60}$$

$$SC = SC_1 + SC_2 + \ldots + SC_n$$

$$AP = AP_1 + AP_2 + \ldots + AP_n$$

$$P = \frac{60 \times (SC_1 + SC_2 + \ldots + SC_n)}{AP_1 + AP_2 + \ldots + AP_n}$$

$$P = \frac{(AP_1 \times P_1) + (AP_2 \times P_2) + \ldots + (AP_n \times P_n)}{AP_1 + AP_2 + \ldots + AP_n}$$

$$P = (a_1 \times P_1) + (a_2 \times P_2) + \ldots + (a_n \times P_n)$$

$$AP = TP + RP$$

$$P^* = \frac{60 \times SC}{TP}$$

$$P^* = \frac{AP}{TP} \times P \quad ; \quad P = \frac{TP}{AP} \times P^*$$

$$P = \frac{SC}{\left(\frac{SC_1}{P_1}\right) + \left(\frac{SC_2}{P_2}\right) + \ldots + \left(\frac{SC_n}{P_n}\right)}$$

$$P = \frac{1}{\left(\frac{c_1}{P_1}\right) + \left(\frac{c_2}{P_2}\right) + \ldots + \left(\frac{c_n}{P_n}\right)}$$

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BIOGRAPHICAL SKETCH

Patrick John Bibby was born May 29, 1941, in Chicago, Illinois. He attended elementary school and high school in the Chicago suburb of Libertyville where he was active in football, wrestling, baseball, music, and student organizations. He was graduated from Libertyville High School in 1959.

In the fall of 1959, Patrick enrolled at Illinois State University in Normal, Illinois, as the recipient of a state teacher's scholarship. His major field of study was mathematics. At Illinois State, he earned his varsity letter in track and field, winning the javelin event in the 1962 Iowa Relays, and served as president of the Illinois State Chapter of Kappa Mu Epsilon, a national honorary mathematics society. He received his B.S. and an Outstanding Senior Award in 1963.

From 1963 to 1971, Patrick was a mathematics teacher at Hinsdale Central High School in Hinsdale, Illinois. By attending graduate school during the summer months, he received his M.S. in mathematics from the University of Illinois at Champaign-Urbana in 1967.

From 1971 to 1973, Patrick attended Pennsylvania State University as a graduate assistant in mathematics. He passed the qualifying exams for an Ed.D.

In 1974 Patrick was hired as a mathematics instructor at the South Campus of Miami-Dade Community College. He was appointed chairman of the Mathematics Department there in 1978. During the 1980-81 academic year, he was enrolled in the doctoral program in the Department of Educational Administration and Supervision at the University of Florida.

Patrick currently serves as a member of the Executive Planning Committee for the Gold Coast Section of the Mathematical Association of America. He also maintains membership in the American Association of Community Colleges and the Florida Association of Community Colleges.

Patrick was married to the former Sally Virginia Dausch of Rochester, New York, in 1970. In 1980 they adopted their son, Alexander.

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

James L. Wattenbarger, Chairman
Professor of Educational Administration and Supervision

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

S. Kern Alexander
Professor of Educational Administration and Supervision

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

Albert B. Smith
Professor of Instructional Leadership and Support

This dissertation was submitted to the Graduate Faculty of the Department of Educational Administration and Supervision in the College of Education and to the Graduate Council, and was accepted as partial fulfillment of the requirements for the degree of Doctor of Philosophy.

December, 1983

Dean, Graduate School